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AFATL-TR-76-138

LOAD ANALYSIS AND CRITICAL AREA STRESS ANALYSIS OF THE 126-AR00036 AND 126-AR00037 PARACHUTE TESTERS WHEN INSTALLED ON THE F-4C/D AIRCRAFT CENTERLINE STATION

AIRCRAFT COMPATIBILITY BRANCH
MUNITIONS DIVISION

NOVEMBER 1976

FINAL REPORT: JULY 1976 TO OCTOBER 1976

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This report documents the loads and critical stress analyses performed on the two stores: 126-AR00036 and 126-AR00037. These stores are two parachute testing vehicles used by the 6511th Test Sq/DORER for evaluation of various parachutes.

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PREFACE

This report covers part of the work performed in support of Project AFSCG021 during the period July 1976 through October 1976 by the Structures Team of the Aircraft Compatibility Branch, Munitions Division, Air Force Armament Laboratory (AFATL), Eglin Air Force Base, Florida. Mr. William W. Dyess, Jr (DLJC) was program manager for the effort.

This report has been reviewed and is approved for publication.

FOR THE COMMANDER

Charles Petrides

CHARLES PETRIDES, GS-15
Technical Director
Munitions Division

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SECTION I

INTRODUCTION

The Aircraft Compatibility Branch of the Air Force Armament Laboratory is responsible for reviewing and issuing flight recommendations on all stores flown on Air Force Systems Command aircraft (Reference 1). This report documents the loads and stress analysis performed on two parachute testing vehicles (126-AR00036 and 126-AR00037) used by the 6511th Test Squadron at El Centro, California. These vehicles, a 120-inch model and a 152-inch model, are shown in Figures 1 and 2, respectively. This analysis was necessitated by a request to increase the maximum allowable flight speed of the F-4C/D aircraft with these stores installed on the centerline station.

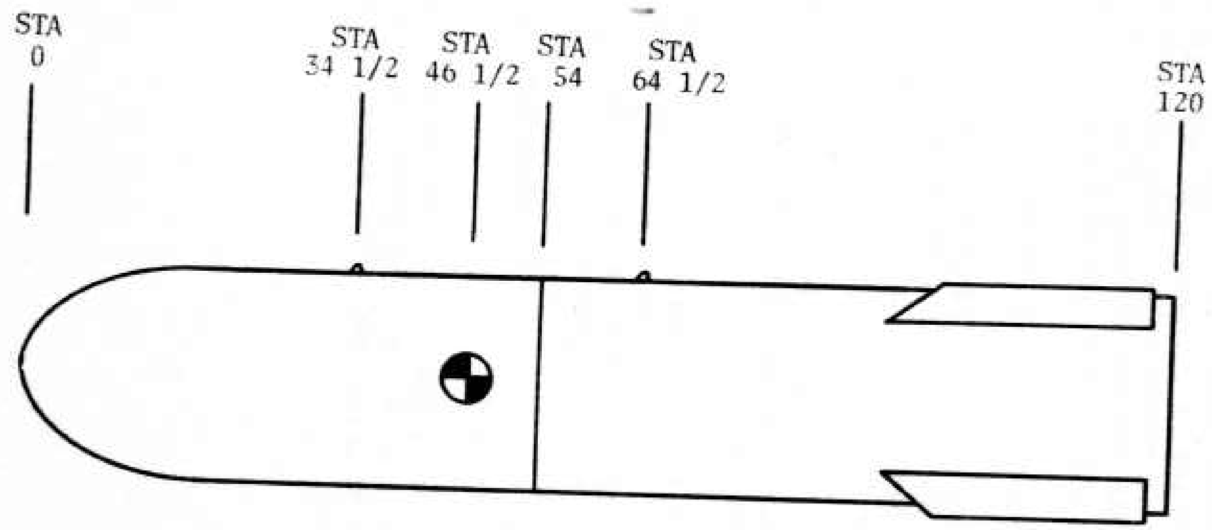
The assumptions made in the analysis are as follows:

1. The vehicle was assumed to be of homogeneous mass distribution from the center of gravity (cg) forward and from the cg aft. This will generate conservative shears and moments but, due to the composition of the vehicle, the assumption is not unreasonable.

2. A reduced αq and βq, as defined in MIL-A-8591D (Reference 2), are used. These reduced values were recommended by McDonnell Aircraft Co. for F-4 centerline application (Reference 3).

3. The maximum stress in the skin would occur just forward or just aft of the lug-strongback section. This is due to assumption 1 and the manner in which the loads are transmitted through the strongback area. Since the section forward of the lug-strongback area is solid material and would have a small moment applied, it is of little concern since the margins would be very high. Thus the only skin area to be investigated will be that just aft of the lug-strongback section.

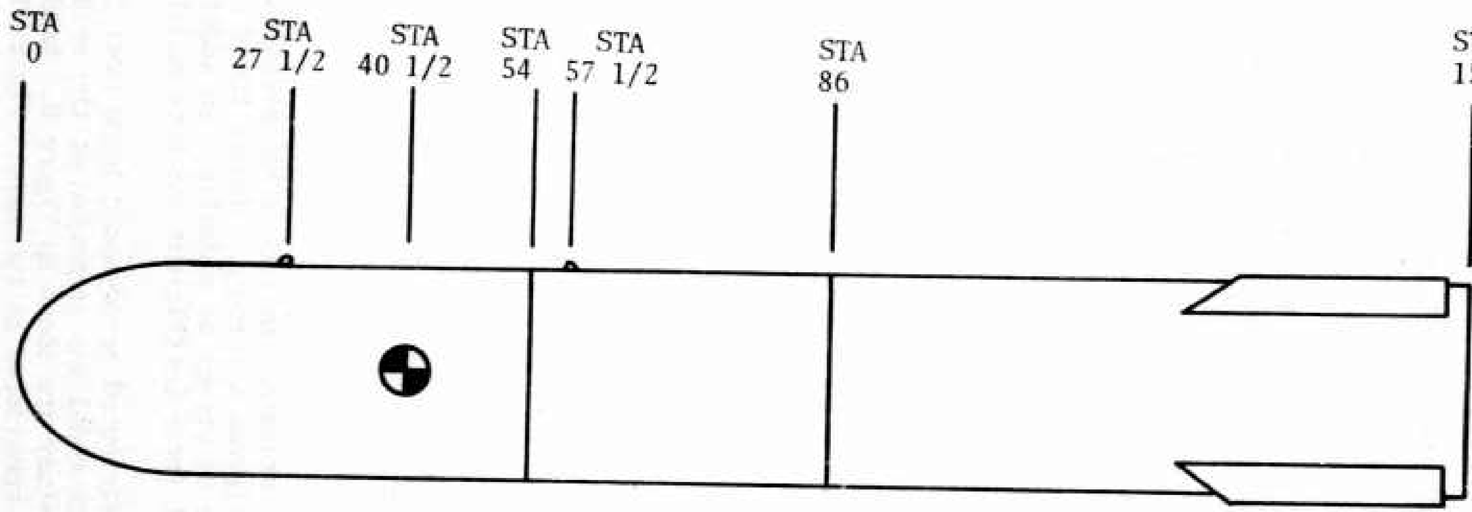
4. The internal structure in rear of vehicles is not load bearing. This assumption must be made since no engineering drawing exists and thus exact load relationships cannot be determined. This assumption will result in a conservative stress analysis.



MATERIAL: Nose section is a 2000-pound general-purpose bomb casing, 1/2-inch steel forward-most volume contains 1.2 ft^3 of solid lead. Final 66 inches is 1/4-inch 1020 cold rolled mild steel.

WELD: A butt weld joins these sections.

Figure 1. Outline Drawing of the 120-Inch Model



MATERIAL: Nose section is a 2000-pound general-purpose bomb casing, 1/2-inch steel. First 18 inches are filled with solid lead. Final 98 inches are 1/4-inch 1020 cold rolled mild steel.

WELD: Nose and aft cylinders are butt welded.

Figure 2. Outline Drawing of the 152-Inch Model

SECTION II

AIR LOAD ANALYSES AND AERODYNAMIC DATA

1. DESIGN CAPTIVE FLIGHT

The design captive flight envelope is limited to Mach 0.98. To determine the aerodynamic angles to be used in the analyses, the equations presented in Reference 2, as modified by McDonnell Aircraft Company information presented in Reference 3, are used with dynamic pressure (q) values taken from the perimeter of the captive flight envelope as shown in Figure 3. These equations (with angles in degrees) for the centerline mounted condition are:

Points (1) and (3) (Reference 2)

$$\alpha s = -3 \text{ to } \frac{13{,}000}{q}$$

$$\beta s = \pm \frac{6500}{q}$$

Points (2) and (4) (Reference 2)

$$\alpha s = 0 \text{ to } -\frac{13{,}000}{q}$$

$$\beta s = \pm \frac{6500}{q}$$

Table 1 shows the various values of αs and βs for the four points when the q is varied from 2400 lbf/ft^2 to 800 lbf/ft^2. Considering the design envelope, q can be held at 1200 lbf/ft^2.

2. AERODYNAMIC COEFFICIENT STUDIES

The first study was performed to determine the freestream aerodynamic coefficients for these two models. Figures 4 through 7 depict these coefficients as a function of the angle of attack or sideslip. In addition, a value of 0.4 was used for the axial force coefficient for both models.

The second study computed the distributed aerodynamic loads over the body. For the first case the 120-inch model was segmented at the weldment of station 54. The results of this study are shown in Figure 8. Load distribution for the 152-inch model was considered in two ways: First with a

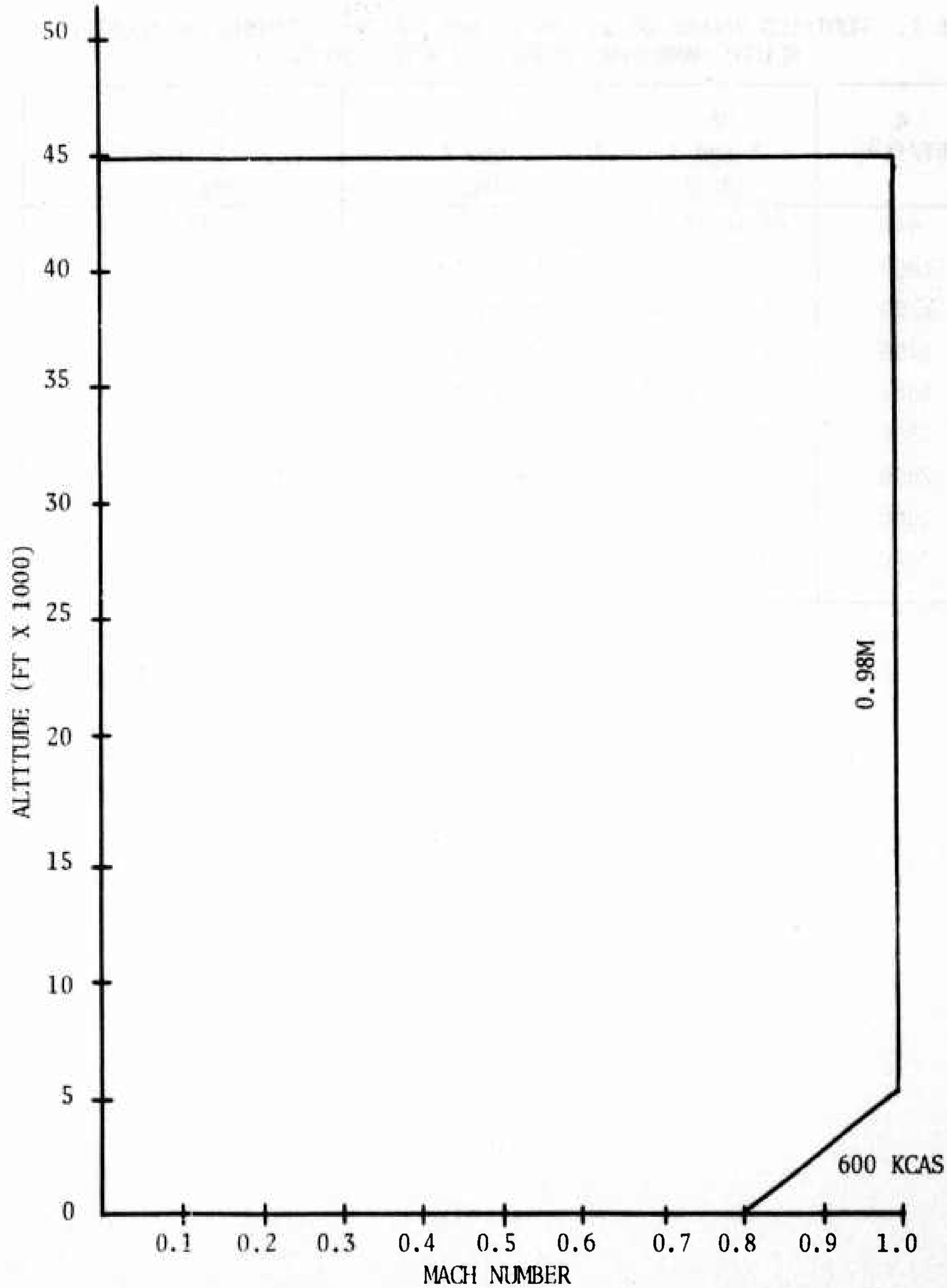


Figure 3. Captive Flight Envelope

TABLE 1. MODIFIED VALUES OF αs AND βs FOR THE FOUR CENTERLINE-MOUNTED FLIGHT MANEUVERS CONDITION WITH VARYING q

q (lbf/ft^2)	αs 1 and 3 (deg)	αs 2 and 4 (deg)	βs 1, 2, 3, and 4 (deg)
800	-3 to 16.25	-16.25 to 0	±8.13
1000	-3 to 13.00	-13.00 to 0	±6.50
1200	-3 to 10.83	-10.83 to 0	±5.42
1400	-3 to 9.29	-9.29 to 0	±4.64
1600	-3 to 8.13	-8.13 to 0	±4.06
1800	-3 to 7.22	-7.22 to 0	±3.61
2000	-3 to 6.50	-6.50 to 0	±3.25
2200	-3 to 5.91	-5.91 to 0	±2.95
2400	-3 to 5.42	-5.42 to 0	±2.71

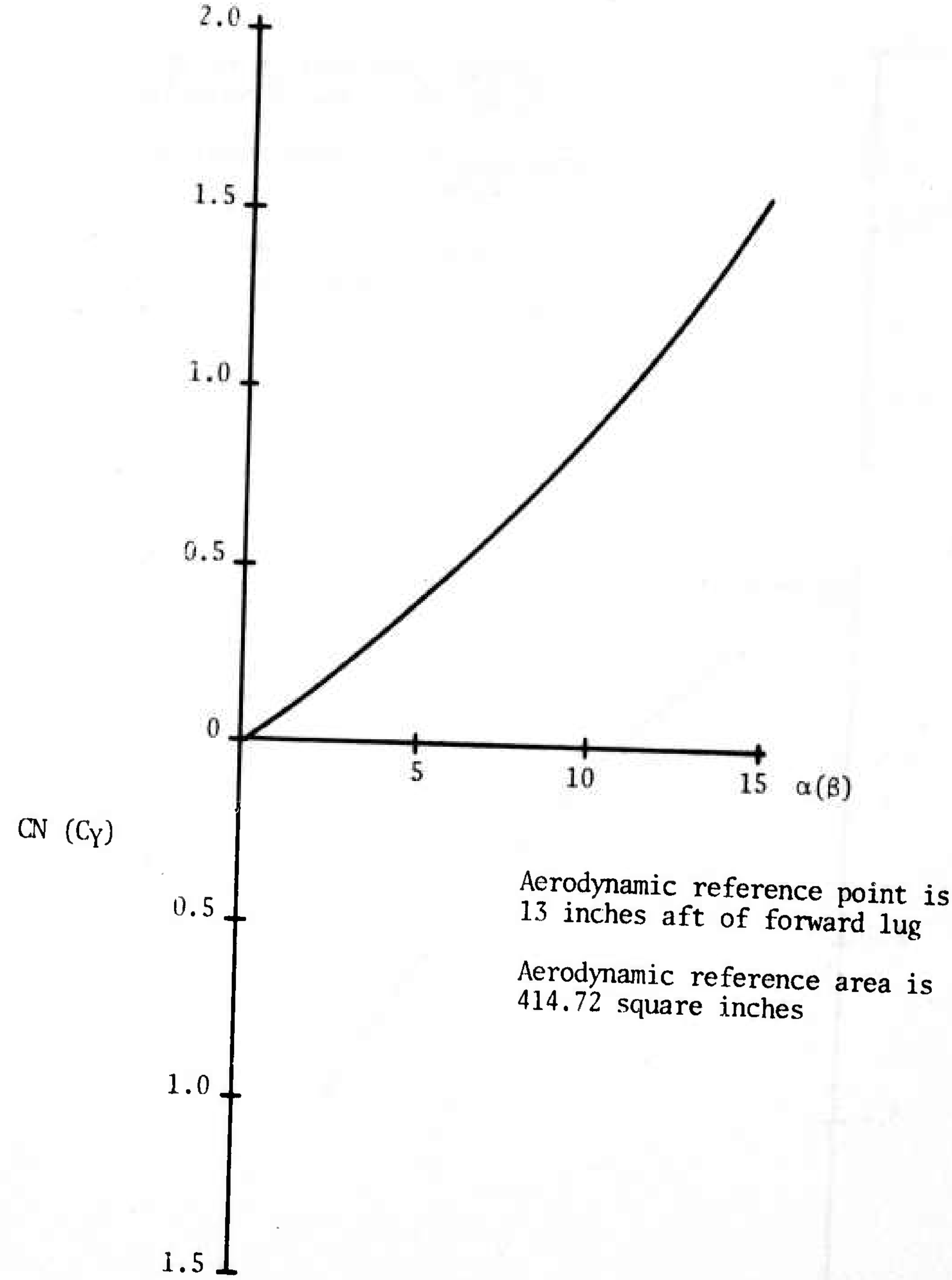


Figure 4. The Aerodynamic Normal (Side) Force Coefficient Versus the Angle of Attack (Sideslip) for the 152-Inch Model

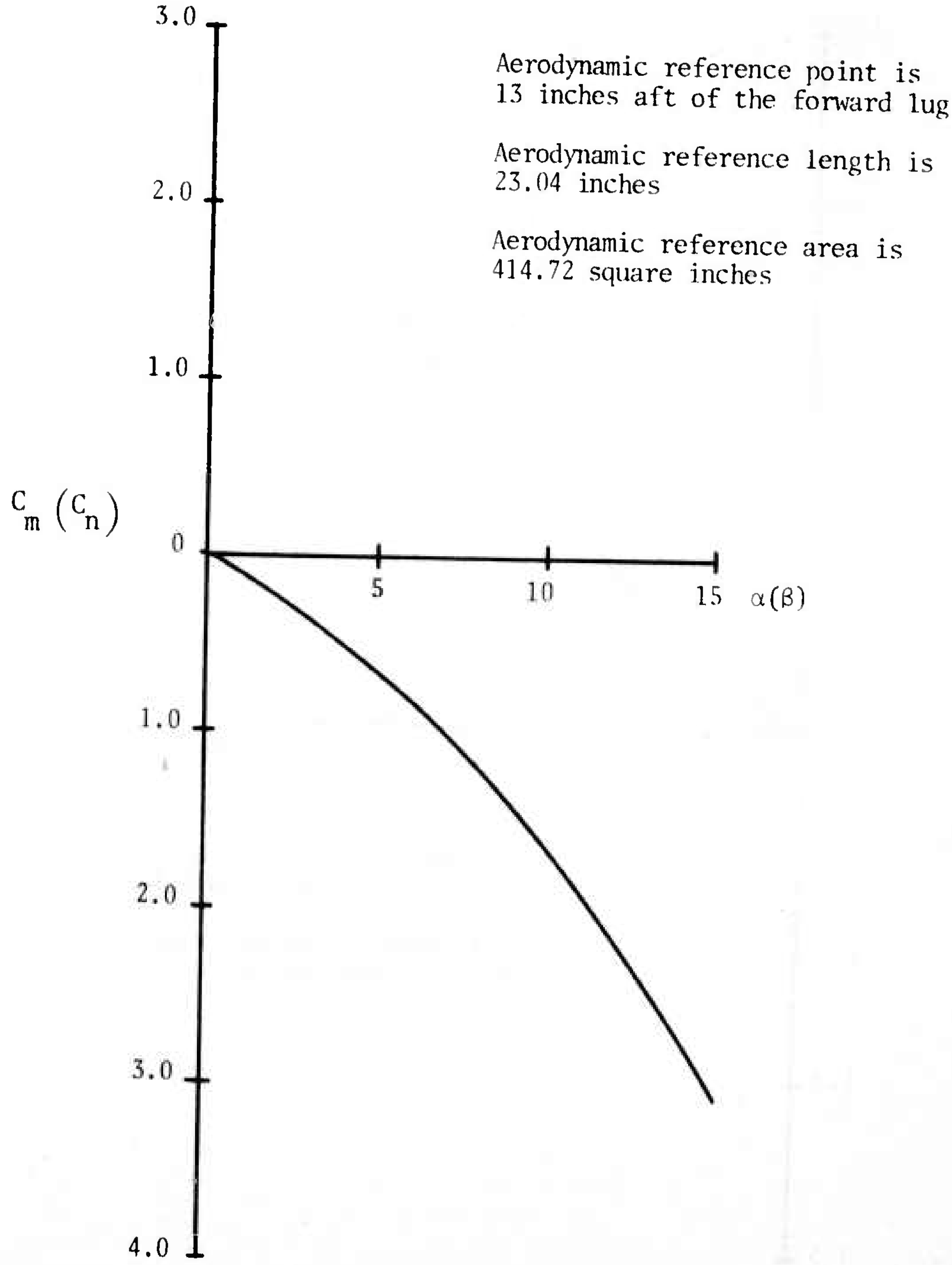


Figure 5. The Aerodynamic Pitching (Yawing) Moment Coefficient Versus the Angle of Attack (Sideslip) for the 152-Inch Model

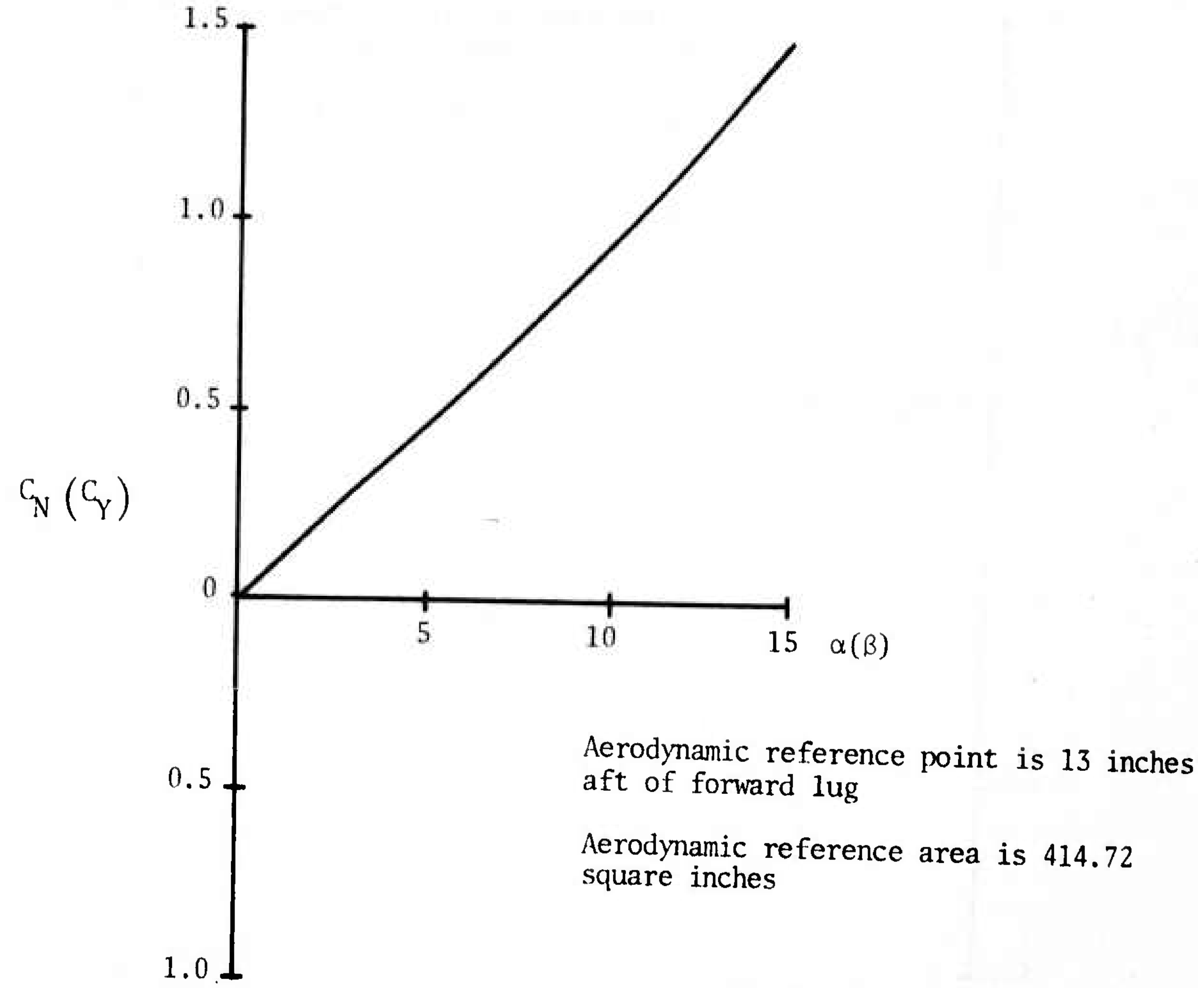


Figure 6. The Aerodynamic Normal (Side) Force Coefficient Versus the Angle of Attack (Sideslip) for 120-Inch Model

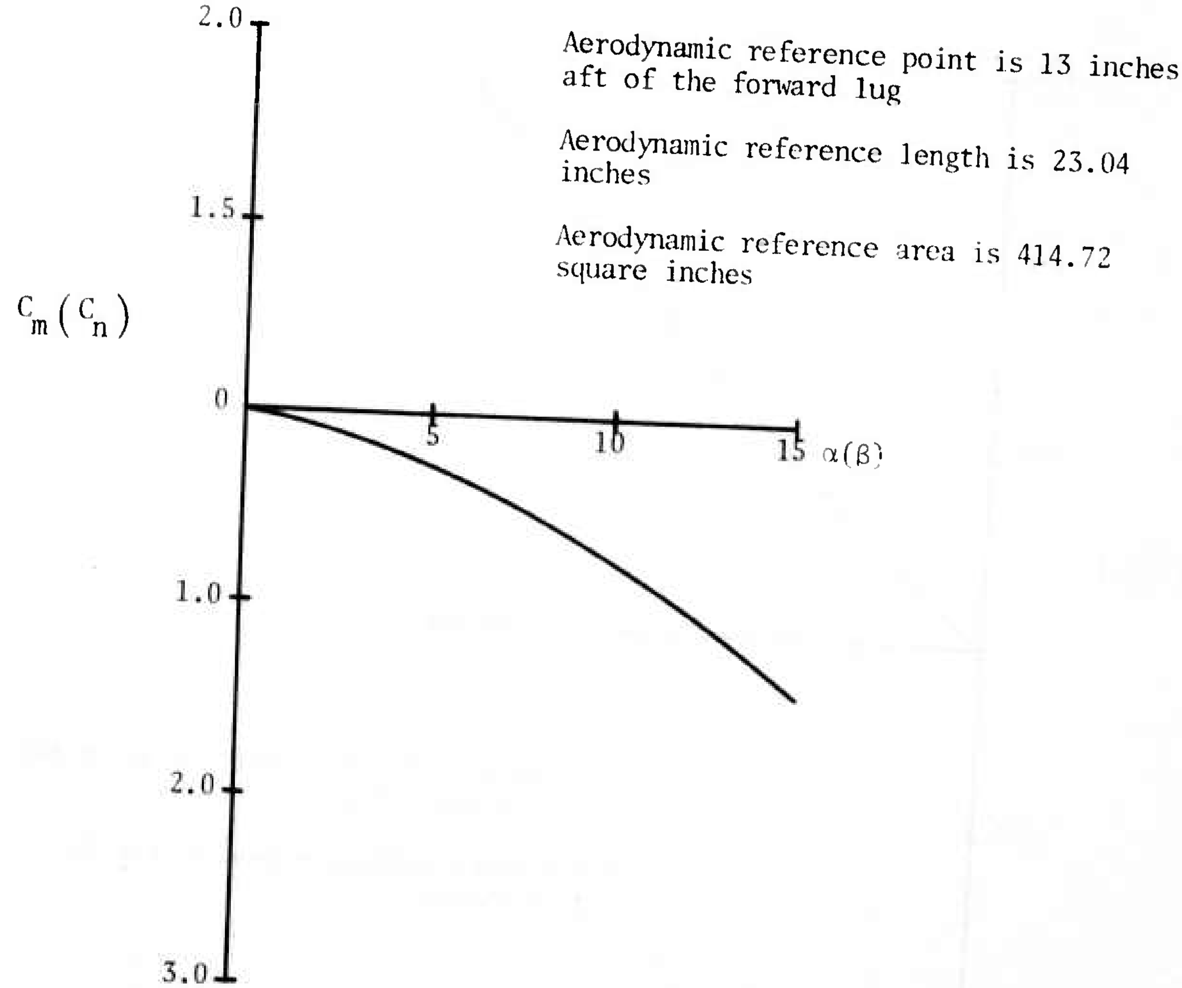
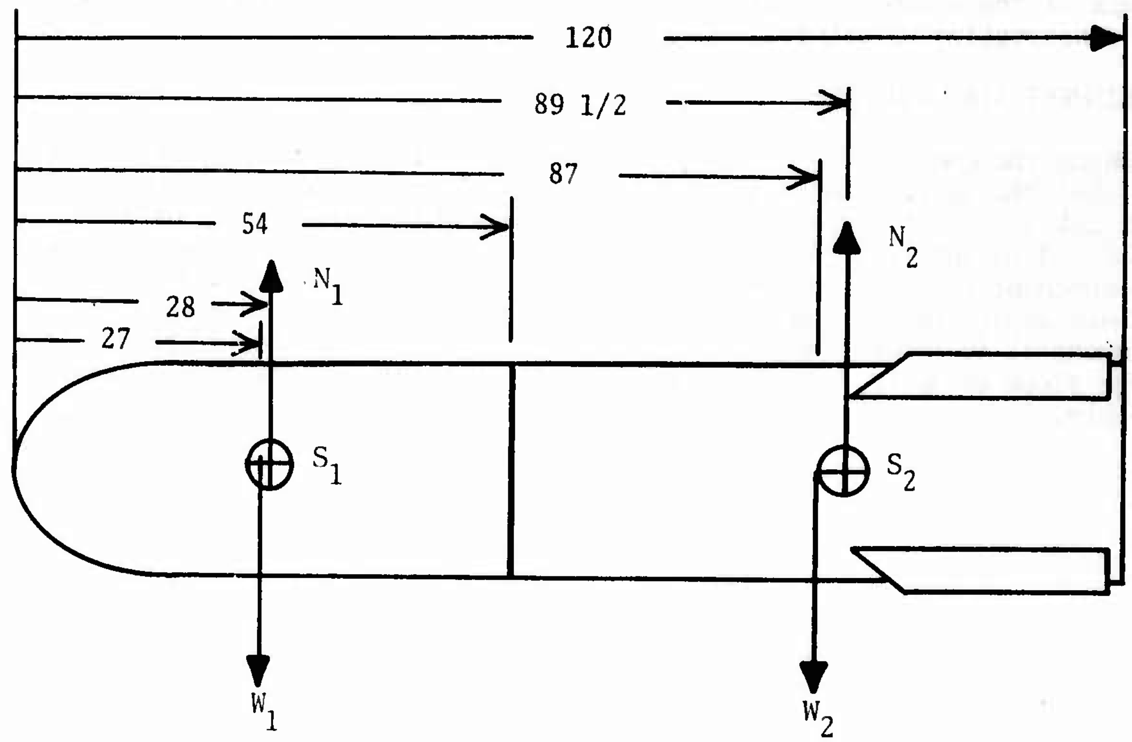


Figure 7. The Aerodynamic Pitching (Yawing) Moment Coefficient Versus the Angle of Attack (Sideslip) for the 120-Inch Model



where:

N_1 = 215 α lb

N_2 = 325 α lb

S_1 = 215 β lb

S_2 = 325 β lb

W_1 = 0.551W lb

W_2 = 0.449W lb

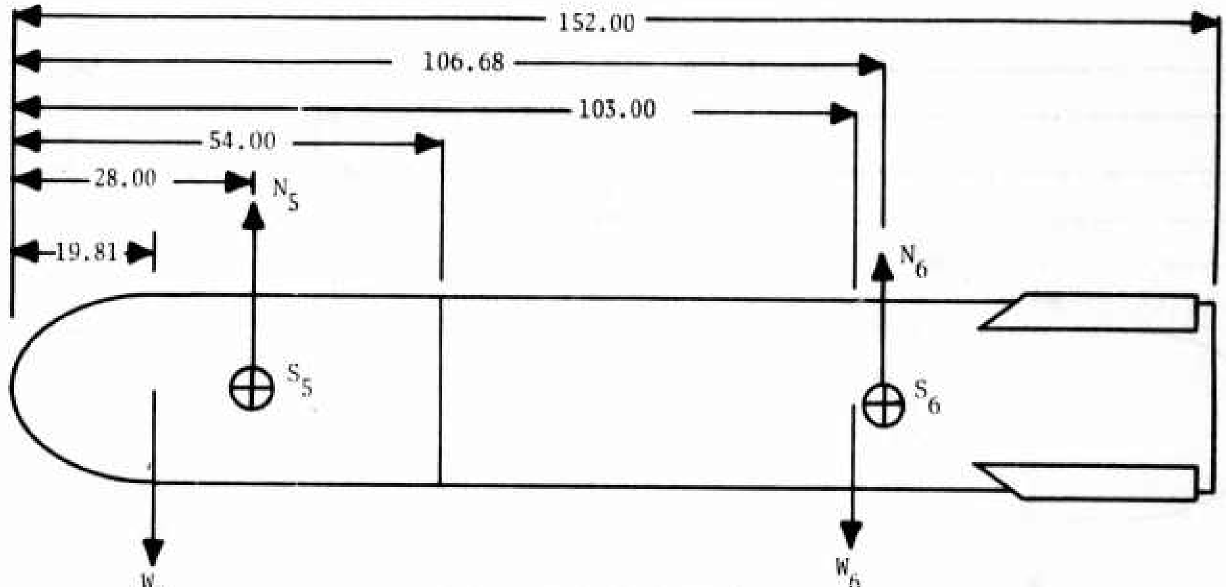
W = Weight of 120-Inch Model

Figure 8. Crude and Conservative Distribution of Loads Existing on the 120-Inch Model

break at the weldment of station 54, shown in Figure 9; and, second, with a break at the weldment of station 86, shown in Figure 10. These analyses were conservative in nature.

3. HIGHEST AIR LOAD CASE

Using the constraints of the problem and the data in Table 1, it can be seen that the maximum angle of attack is 10.83 degrees and the minimum angle of attack is -10.83 degrees. Also, the maximum and minumum angle of sideslip is ±4.64 and -4.64 degrees, respectively. Merely calculating the loads corresponding to these angles may not suffice. In fact, MIL-A-8591D states that all angles in the range should be examined. The reason for this requirement is to insure that if the force or moment curves should break, i.e., change slope abruptly, the final answer will still depict the highest values possible.



All dimensions in inches

where:

N_5 = 213 α lb

N_6 = 458 α lb

S_5 = 213 α lb

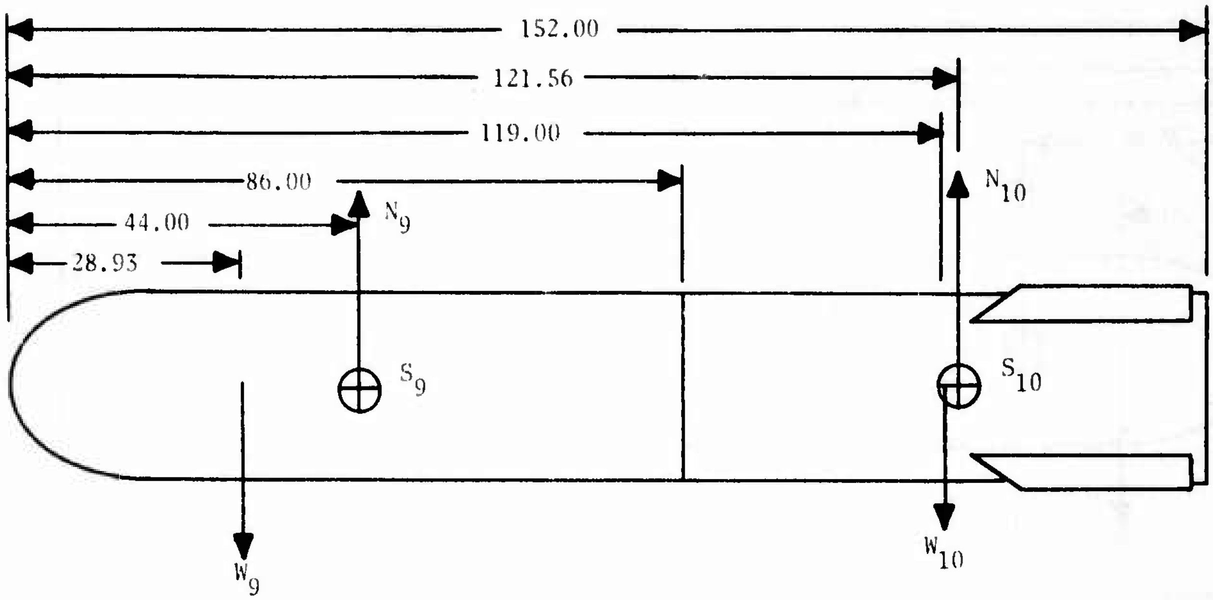
S_6 = 458 α lb

W_5 = 0.405 W lb

W_6 = 0.595 W lb

W = Weight of 152-Inch Model

Figure 9. Crude and Conservative Distribution of Loads Existing on the 152-Inch Model (Station 54)



All dimensions in inches

where:

$N_9 = 860\ \alpha$ lb

$N_{10} = 323\ \alpha$ lb

$S_9 = 860\ \alpha$ lb

$S_{10} = 323\ \alpha$ lb

$W_9 = 0.727\ W$ lb

$W_{10} = 0.273\ W$ lb

Figure 10. Crude and Conservative Distribution of Loads Existing on the 152-Inch Model (Station 86)

SECTION III

INERTIAL LOADS

1. GENERAL

Both models must be capable of sustaining the inertial loads as predicted by MIL-A-8591D. The particular section of this specification employed was that pertaining to stores carried on the centerline of an aircraft. No modifications of the inertial parameters were made corresponding to those made with regard to the aerodynamic coefficients in Section II.

2. INERTIAL PROPERTIES

The weights and centers of gravity (cg) of all sections of interest must be computed. Continuing in the view of using simplifying but conservative assumptions, assume that the model is of homogeneous mass distribution fore and aft of the cg. This means that half of the total weight of the model in question is evenly distributed along the space forward of the cg and half of the weight aft. Thus, the linear weight for the 120-inch model can be computed as

$$W^a_{1_{120}} = \frac{1}{2} W/(120-46\ 1/2)$$

$$W^a_{1_{120}} = \frac{W}{147}$$

$$W^f_{1_{120}} = \frac{W}{93}$$

where

$W^a_{1_{120}}$ is the linear weight of the section aft of the overall cg of the 120-inch model

$W^f_{1_{120}}$ is the linear weight of the section forward of the overall cg of the 120-inch model

W is the weight of the model

and the linear weight for the 152-inch model can be computed as

$$W^a_{1_{152}} = \frac{1}{2} W/(152 - 31)$$

$$W^a_{1_{152}} = \frac{W}{242}$$

$$W^f_{1_{152}} = \frac{W}{62}$$

where

$W^a_{1_{152}}$ is the linear weight of the section aft of the overall cg of the 152-inch model

$W^f_{1_{152}}$ is the linear weight of the section forward of the overall cg of the 152-inch model.

Now with these linearized weights, it is possible to obtain the values desired. Representative values are shown in Figures 8 and 9 and calculations are as follows:

a. Station 0 to Station 54 of the 120-inch vehicle

$$W_1 = (46\ 1/2)\ W^f_{1_{120}} + (54 - 46\ 1/2)\ W^a_{1_{120}}$$

$$W_1 = 0.551W$$

$$(cg)_1 = 26.44 \text{ (Station)}$$

b. Station 54 to Station 120 of 120-inch vehicle

$$W_2 = (120 - 46\ 1/2)\ W^a_{1_{120}}$$

$$W_2 = 0.449W$$

$$(cg)_2 = 87.00 \text{ (Station)}$$

c. Station 0 to Station 65 of 120-inch vehicle

$$W_3 = (46\ 1/2)\ W^f_{1_{120}} + (65 - 46\ 1/2)\ W^a_{1_{120}}$$

$$W_3 = 0.626W$$

$$(cg)_3 = 29.79 \text{ (Station)}$$

d. Station 65 to Station 120 of 120-inch vehicle

$$W_4 = (120 - 65)\ W^a_{1_{120}}$$

$$W_4 = 0.374W$$

$$(cg)_4 = 92.50 \text{ (Station)}$$

e. Station 0 to Station 54 of 152-inch vehicle

$$W_5 = (31)\ W^f_{1_{152}} + (54 - 31)\ W^a_{1_{152}}$$

$$W_5 = 0.595W$$

$$(cg)_5 = 19.81 \text{ (Station)}$$

f. Station 54 to Station 152 of 152-inch vehicle

$$W_6 = (152 - 54)\ W^a_{1_{152}}$$

$$W_6 = 0.405W$$

$$(cg)_6 = 103.00 \text{ (Station)}$$

g. Station 0 to Station 58 of 152-inch vehicle

$$W_7 = (31)\, W^f_{1_{152}} + (58 - 31)\, W^a_{1_{152}}$$

$$W_7 = 0.612W$$

$$(cg)_7 = 20.81 \text{ (Station)}$$

h. Station 58 to Station 152 of 152-inch vehicle

$$W_8 = (152 - 58)\, W^a_{1_{152}}$$

$$W_8 = 0.388W$$

$$(cg)_8 = 105.00 \text{ (Station)}$$

i. Station 0 to Station 86 of 152-inch vehicle

$$W_9 = (31)\, W^f_{1_{152}} + (86 - 31)\, W^a_{1_{152}}$$

$$W_9 = 0.727W$$

$$(cg)_9 = 28.93 \text{ (Station)}$$

j. Station 86 to Station 152 of 152-inch vehicle

$$W_{10} = (152 - 86)\, W^a_{1_{152}}$$

$$W_{10} = 0.273W$$

$$(cg)_{10} = 119.00 \text{ (Station)}$$

SECTION IV

COMBINED LOADING ON VEHICLES AT CRITICAL AREAS

1. GENERAL

To make the analysis as conservative as possible, the maximum angle of sideslip and attack were considered with the maximum inertial factors determined for a rolling-pull-out (RPO) maneuver. This is corner 2 of Figure 11. The aerodynamic angles are assumed to be of appropriate sense to allow the aerodynamic and inertial loads to couple.

Since the cross section is symmetrical, an equivalent load factor and aerodynamic angle as shown in Figure 12 can be obtained. In addition, the total weight spread of each vehicle will be examined.

2. LOADS AT STATION 54 OF 120-INCH VEHICLE

From Figure 8, the shear at the cross section would be

$$S_{54/120} = N_2 + W_2$$

$$= 215\alpha + 0.449\ W\eta$$

$$= 215\ (11.78) + (0.449)\ (2600)\ (8.79)$$

$$= 12{,}794\ \text{lb}$$

and the moment would be

$$M_{54/120} = (89\ 1/2 - 54)\ N_2 + (87 - 54)\ W_2$$

$$= (35.5)\ N_2 + (33)\ W_2$$

$$= 428{,}538\ \text{in-lb}$$

3. LOADS AT STATION 65 OF 120-INCH VEHICLE

From Figure 8, the shear at the cross section would be

$$S_{65/120} = N_4 + W_4$$

$$= 215\alpha + 0.374\ W\eta$$

$$= 215\ (11.78) + (0.374)\ (26.00)\ (8.79)$$

$$= 11{,}080\ \text{lb}$$

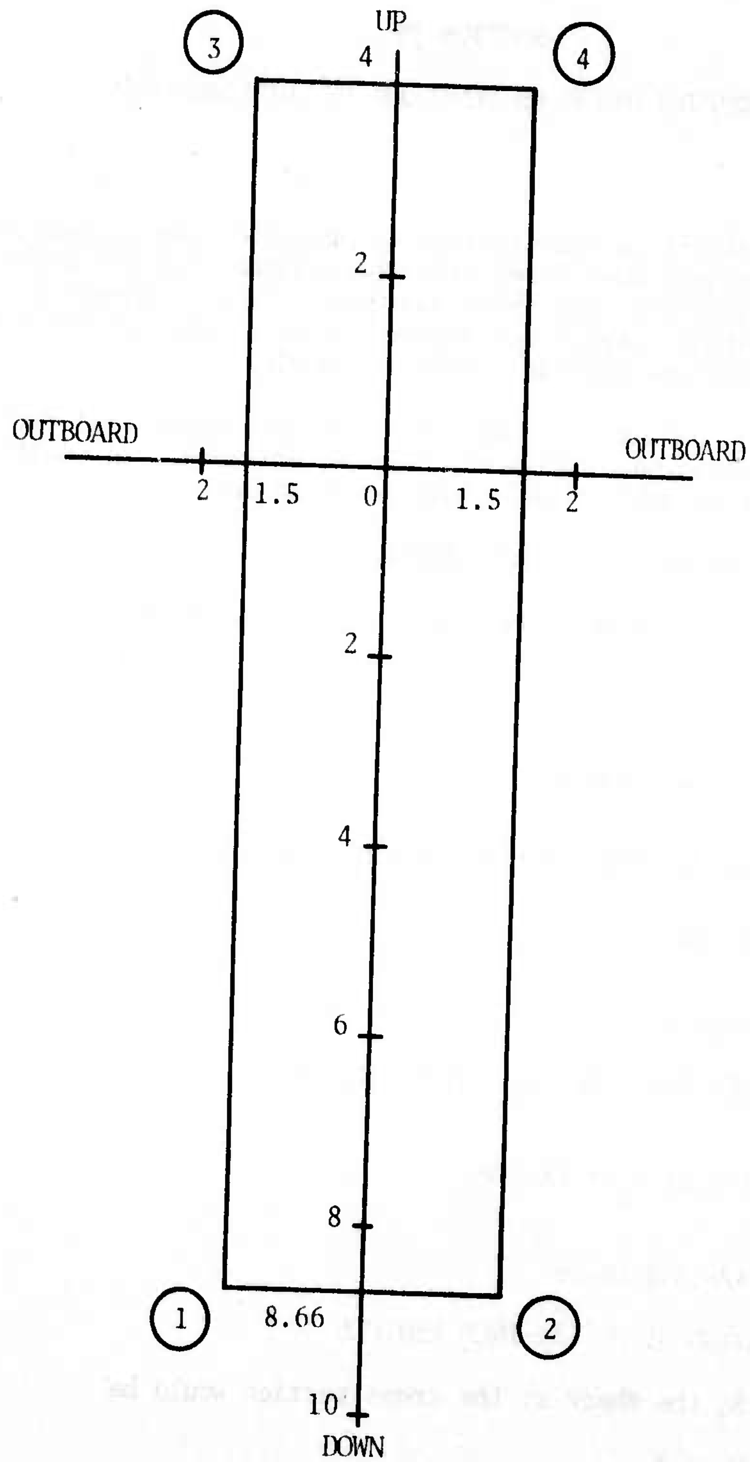


Figure 11. Design Limit Load Factor for Fuselage-Mounted Stores as per Reference 2

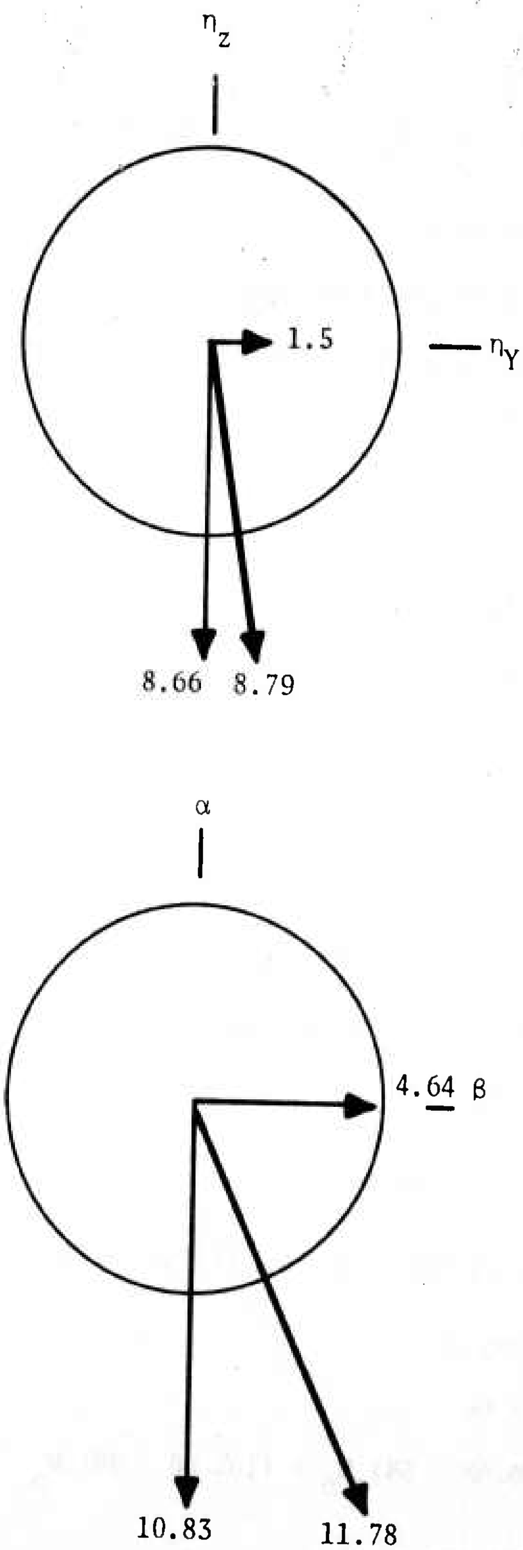


Figure 12. Maximum Resultant for Inertial Load Factor (η) and Aerodynamic Angle

and the moment would be

$$M_{65/120} = (89.5) - 65)\ N_4 + (92.5 - 65)\ W_4$$

$$= 297{,}104 \text{ in-lb}$$

4. LOADS AT STATION 54 OF 152-INCH VEHICLE

From Figure 9, the shear at the cross section would be

$$S_{54/152} = N_6 + W_6$$

$$= 458\alpha + 0.595\ W\eta$$

$$= 458\ (11.78) + (0.595)\ (6275)\ (8.79)$$

$$= 32{,}818 \text{ lb}$$

and the moment would be

$$M_{54/152} = (106.68 - 54)\ N_6 + (103 - 54)\ W_6$$

$$= 1{,}892{,}330 \text{ in-lb}$$

5. LOADS AT STATION 58 OF 152-INCH VEHICLE

From Figure 9, the shear at the cross section would be

$$S_{58/152} = N_8 + W_8$$

$$= 458\alpha + 0.388\ W\eta$$

$$= 458\ (11.78) + (0.388)\ (6275)\ (8.79)$$

$$= 26{,}796 \text{ lb}$$

and the moment would be

$$M_{58/152} = (106.68 - 58)\ N_6 + (105.00 - 58)\ W_6$$

$$= 1{,}268{,}487 \text{ in-lb}$$

6. LOADS AT STATION 86 OF 152-INCH VEHICLE

From Figure 10, the shear at the cross section would be

$$S_{86/152} = N_{10} + W_{10}$$

$$= 323\alpha + 0.273\ W\eta$$

$$= 323\ (11.78) + 0.273\ (6275)\ (8.79)$$

$$= 18{,}862\ \text{lb}$$

and the moment would be

$$M_{86/152} = (121.56 - 86)\ N_{10} + (119 - 86)\ W_{10}$$

$$= 632{,}215\ \text{in-lb}$$

7. LOADS AT VEHICLE - RACK INTERFACE OF 120-INCH VEHICLE

A run using the procedures of MIL-A-8591 was accomplished. The results of this analysis are presented in Figures 13 through 20. The support data for these relationships may be obtained from the author upon request.

8. LOADS AT VEHICLE - RACK INTERFACE OF 152-INCH VEHICLE

An analysis similar to the one above was accomplished for the 152-inch vehicle. The results are presented in Figures 21 through 28. The support data may be obtained from the author upon request.

9. LOADS ON VEHICLE FINS

The fins for both vehicles have a wetted surface area of 150 square inches each (6x25). Assuming that the maximum normal force coefficient will not exceed the flat plate drag coefficient of 1.28 the maximum normal force (N_F) is computed as

$$N_F = C_N\ q\ A$$

$$N_F = (1.28)\ (1200)\ (1.04)$$

$$N_F = 1600\ \text{lb}$$

The weight of the fin is unknown, but it is assumed that the inertial loads would be small compared to the aerodynamic loads.

Thus, conservatively assuming that the load is acting at the fin centroid, we have the following shear and moment at the fin root

$$S = 1600 \text{ lb}$$

$$M = 3(1600)$$

$$M = 4800 \text{ in-lb.}$$

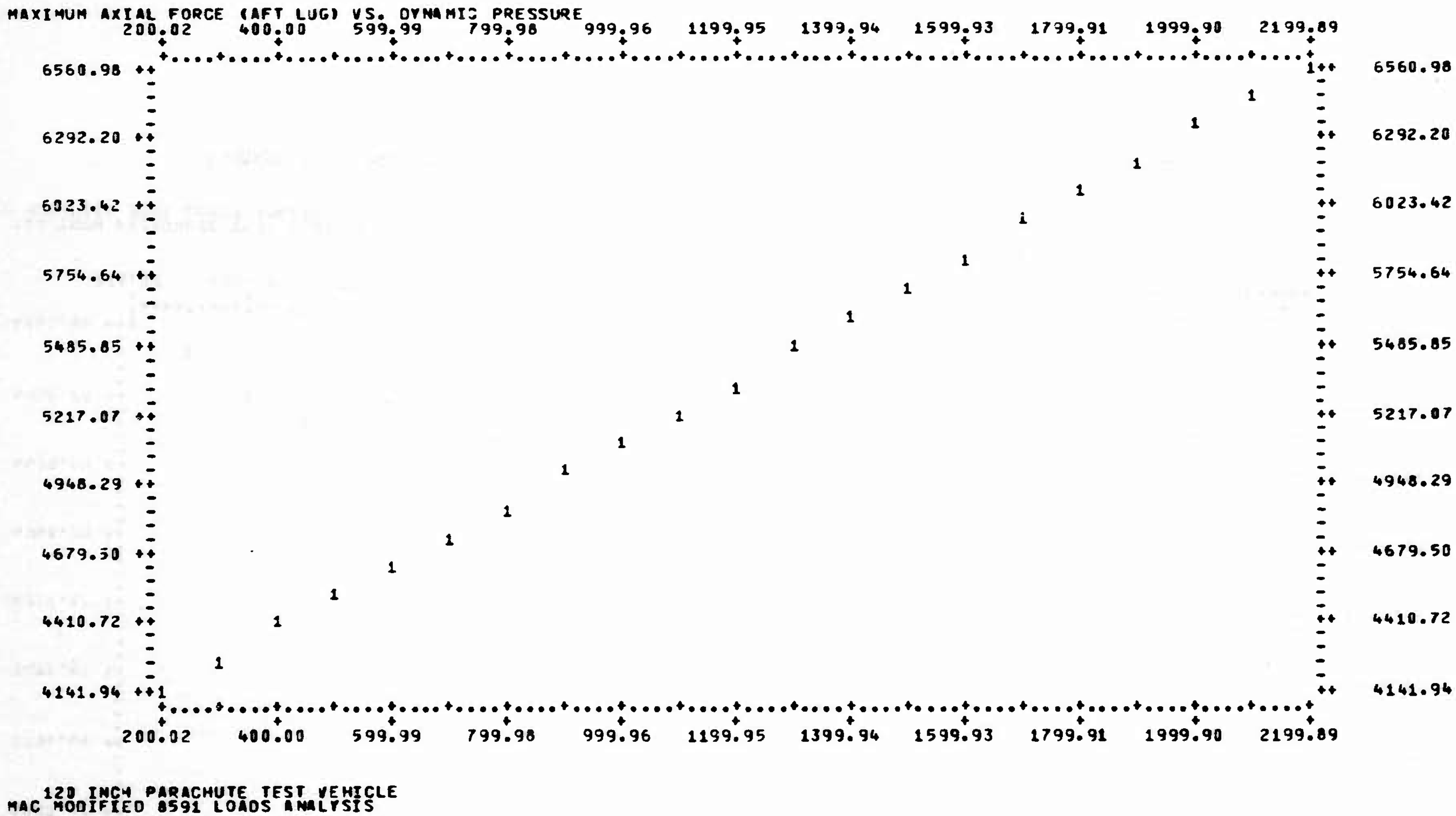


Figure 13. Maximum Axial Force on the Aft Lug Versus Dynamic Pressure for the 120-Inch Vehicle

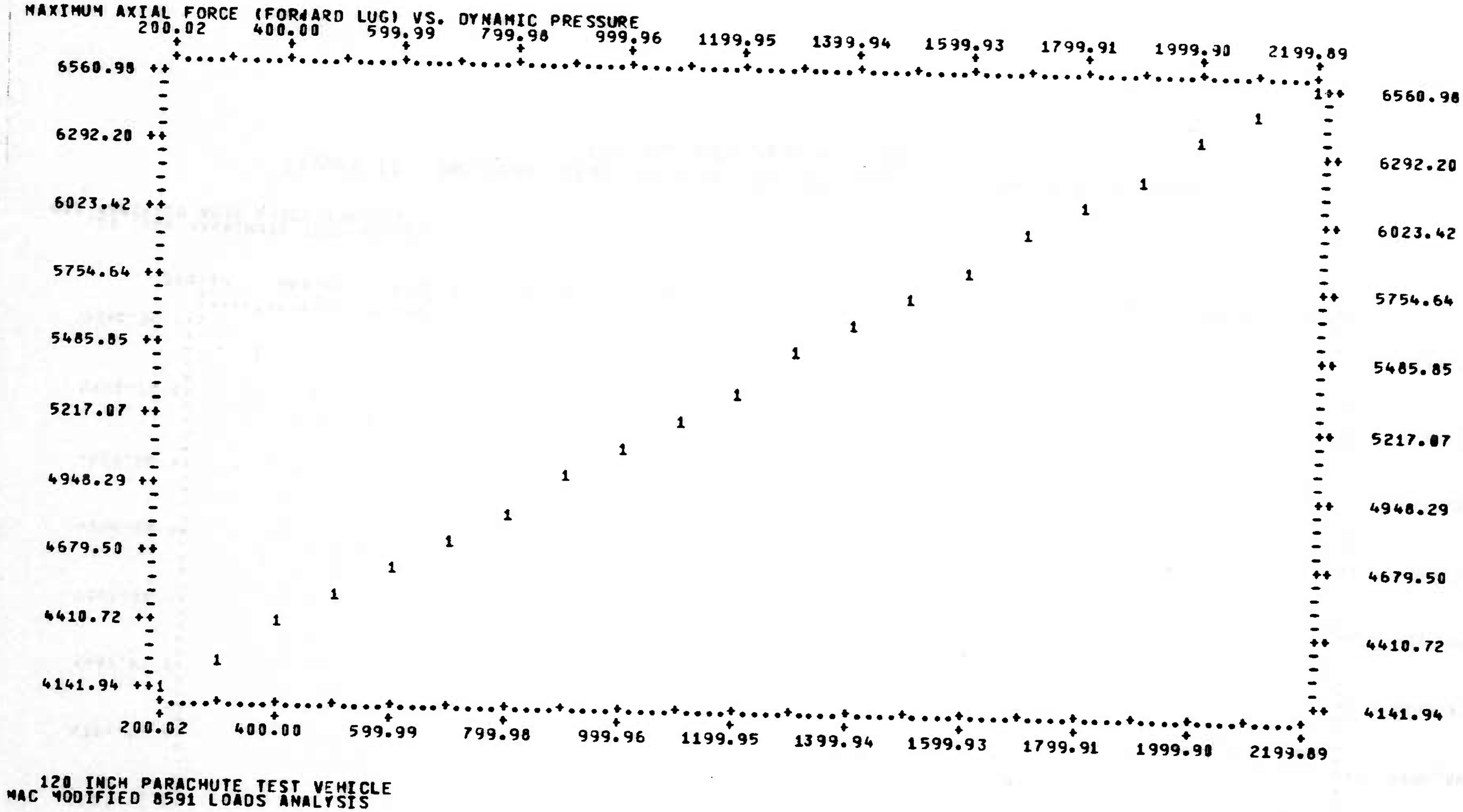


Figure 14. Maximum Axial Force on the Forward Lug Versus Dynamic Pressure for the 120-Inch Vehicle

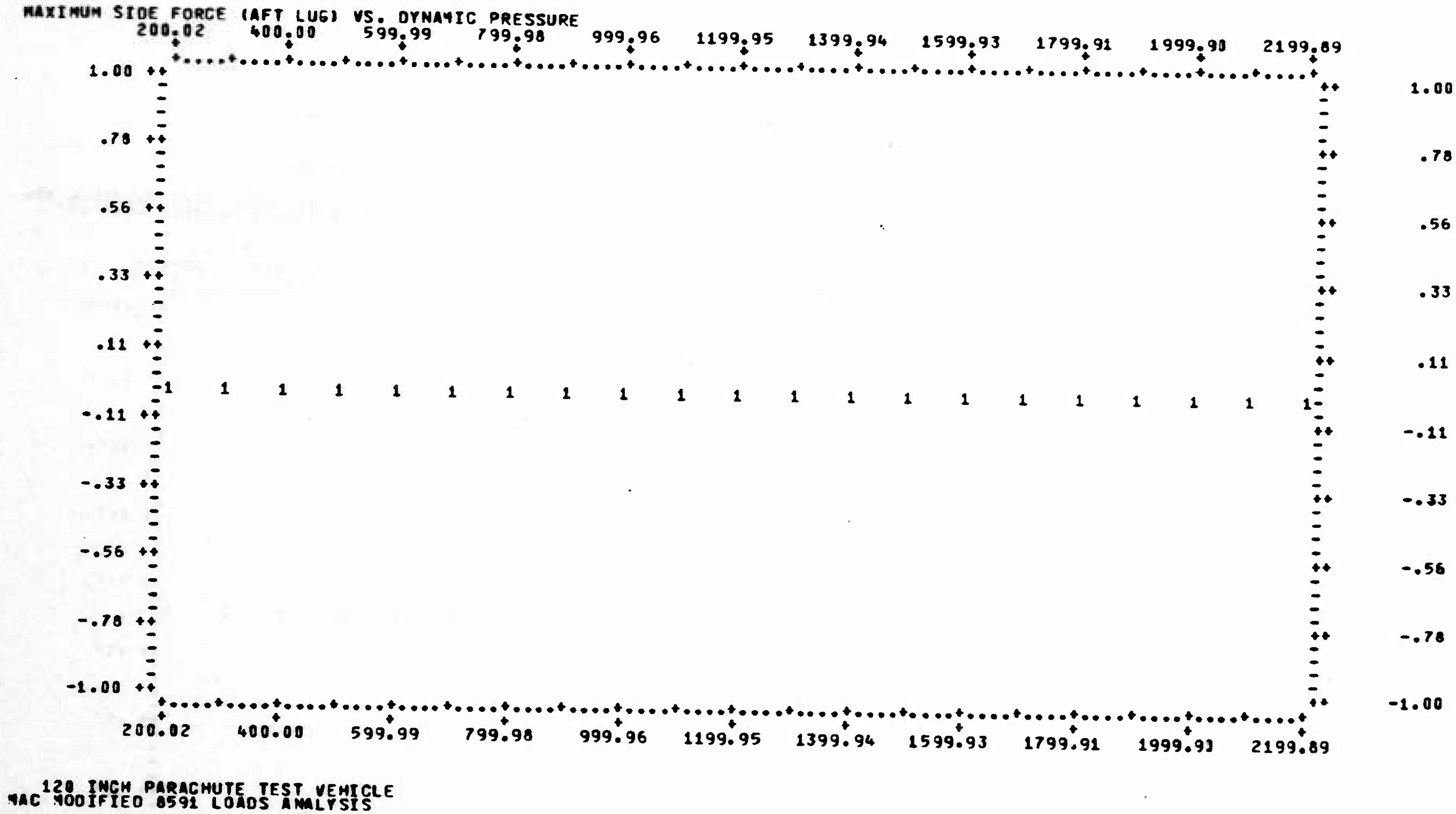


Figure 15. Maximum Side Force on the Aft Lug Versus Dynamic Pressure for the 120-Inch Vehicle

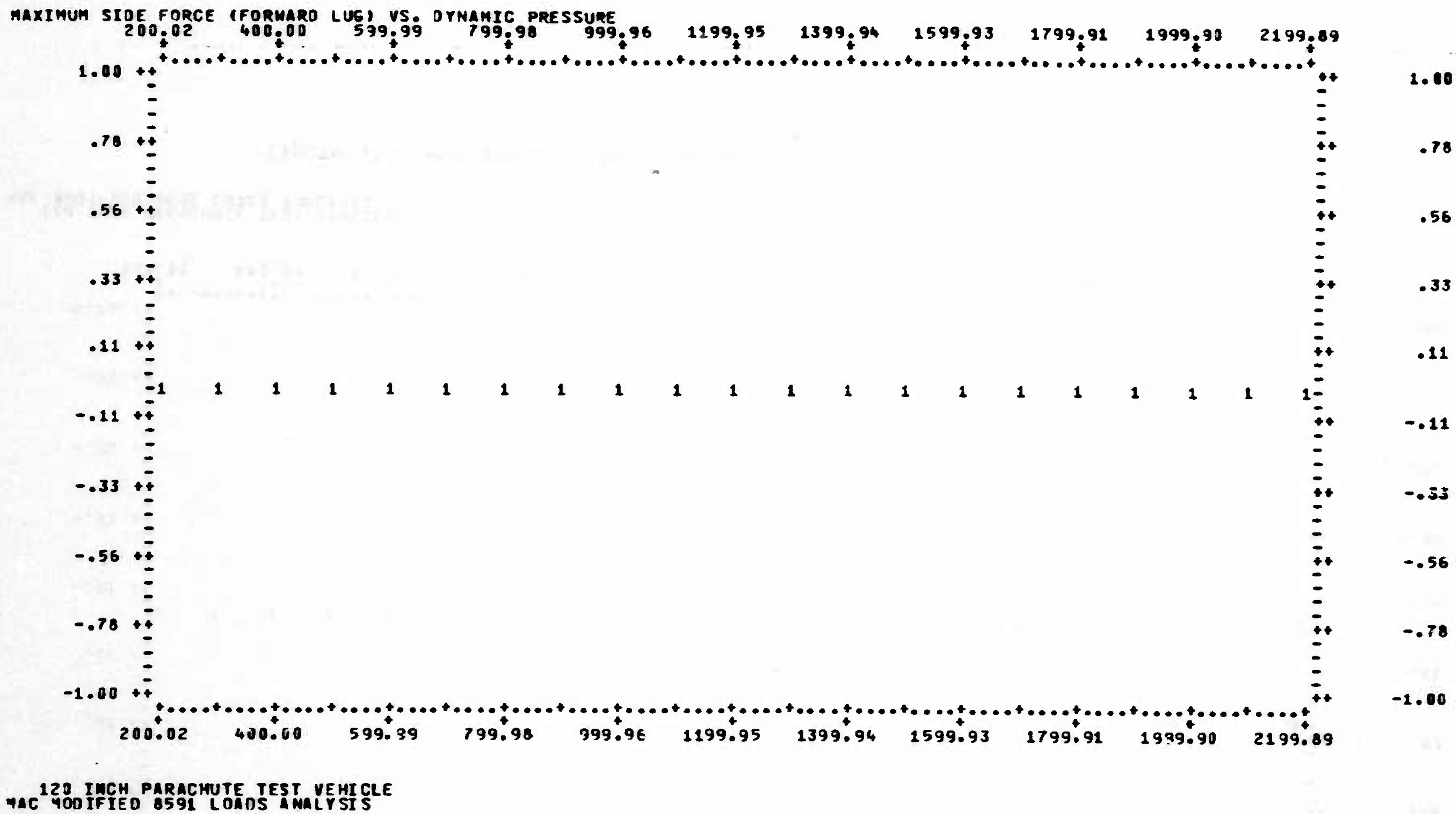


Figure 16. Maximum Side Force on the Forward Lug Versus Dynamic Pressure for the 120-Inch Vehicle

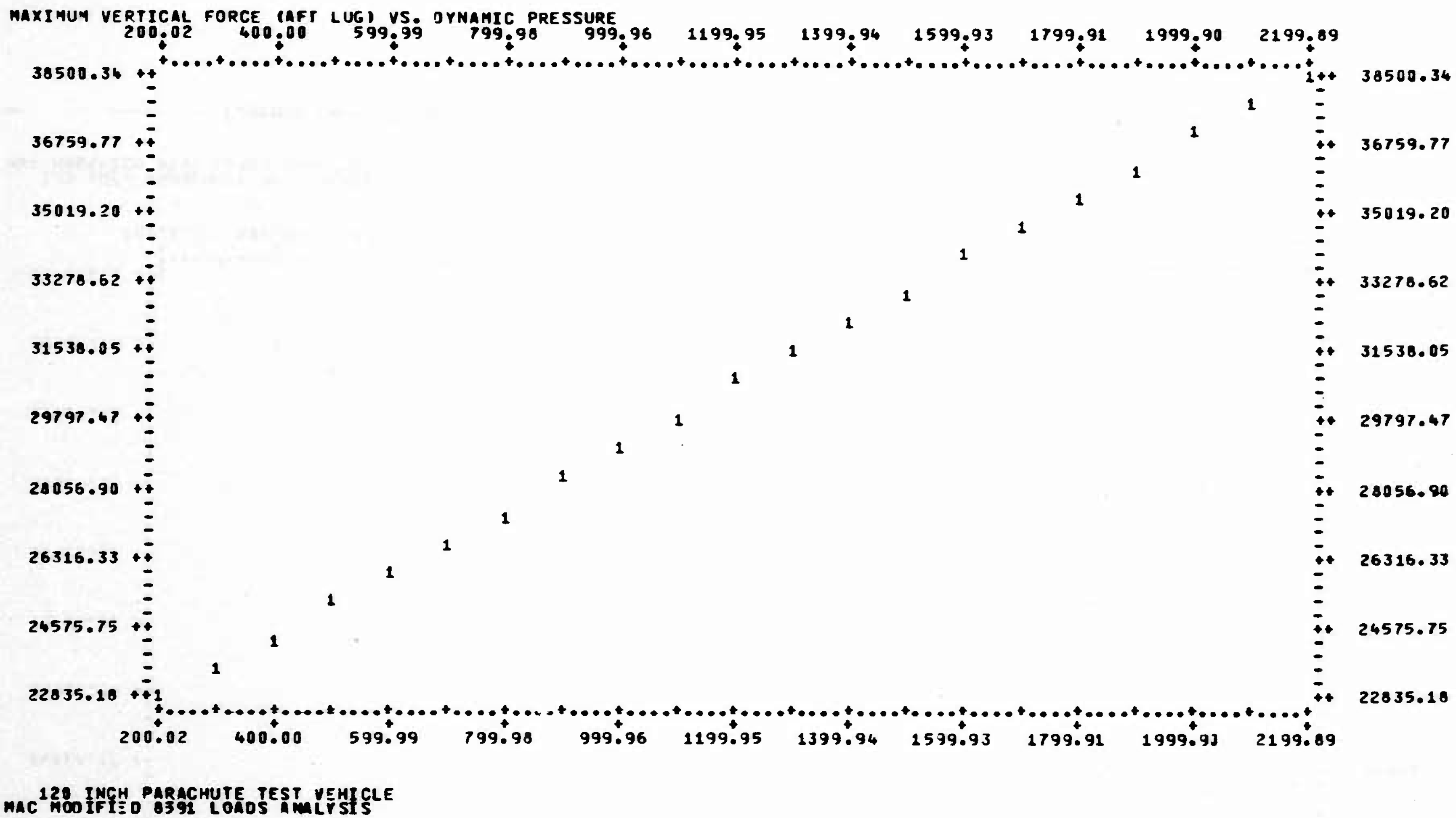


Figure 17. Maximum Vertical Force on the Aft Lug Versus Dynamic Pressure for the 120-Inch Vehicle

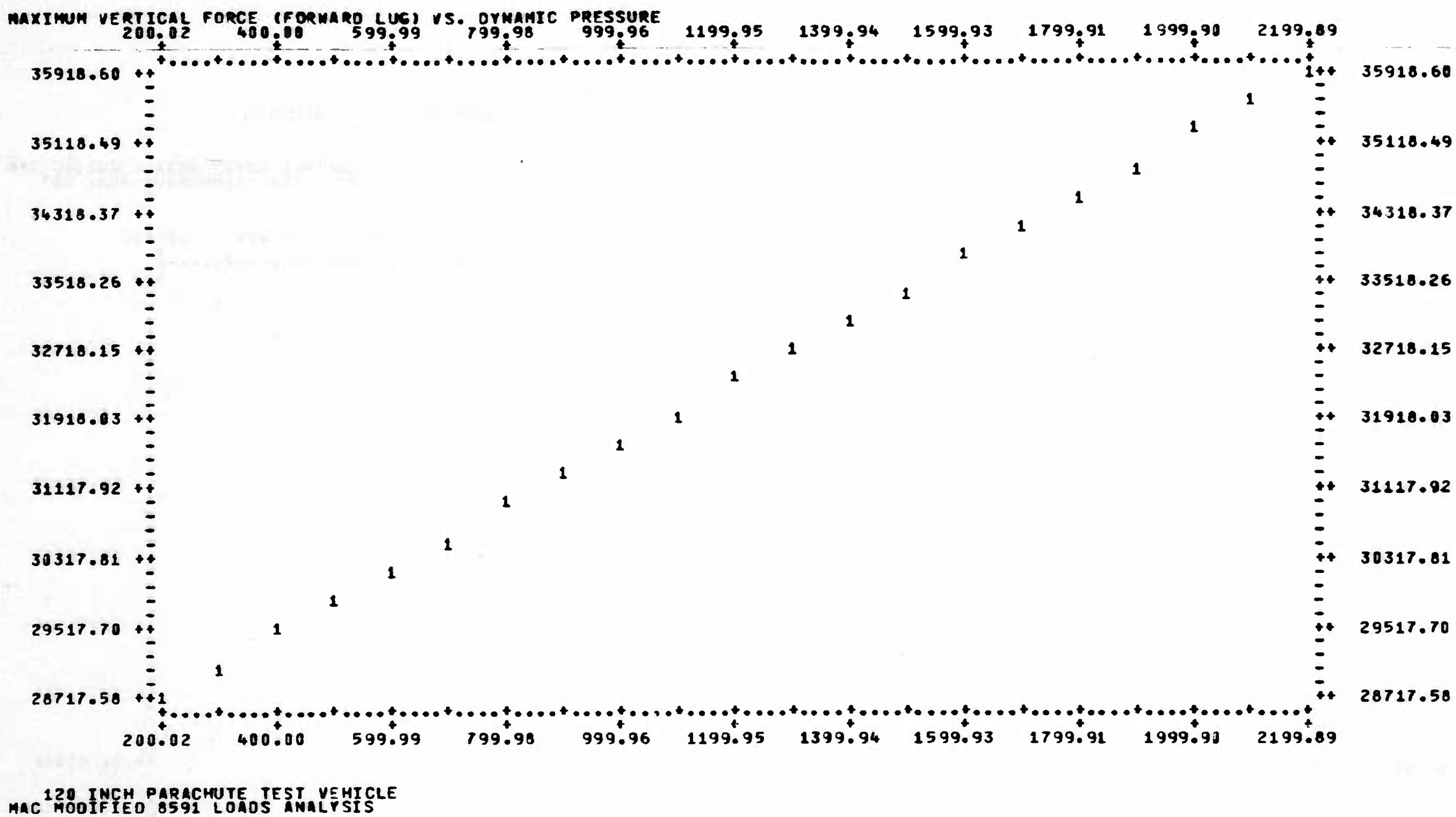


Figure 18. Maximum Vertical Force on the Forward Lug Versus Dynamic Pressure for the 120-Inch Vehicle

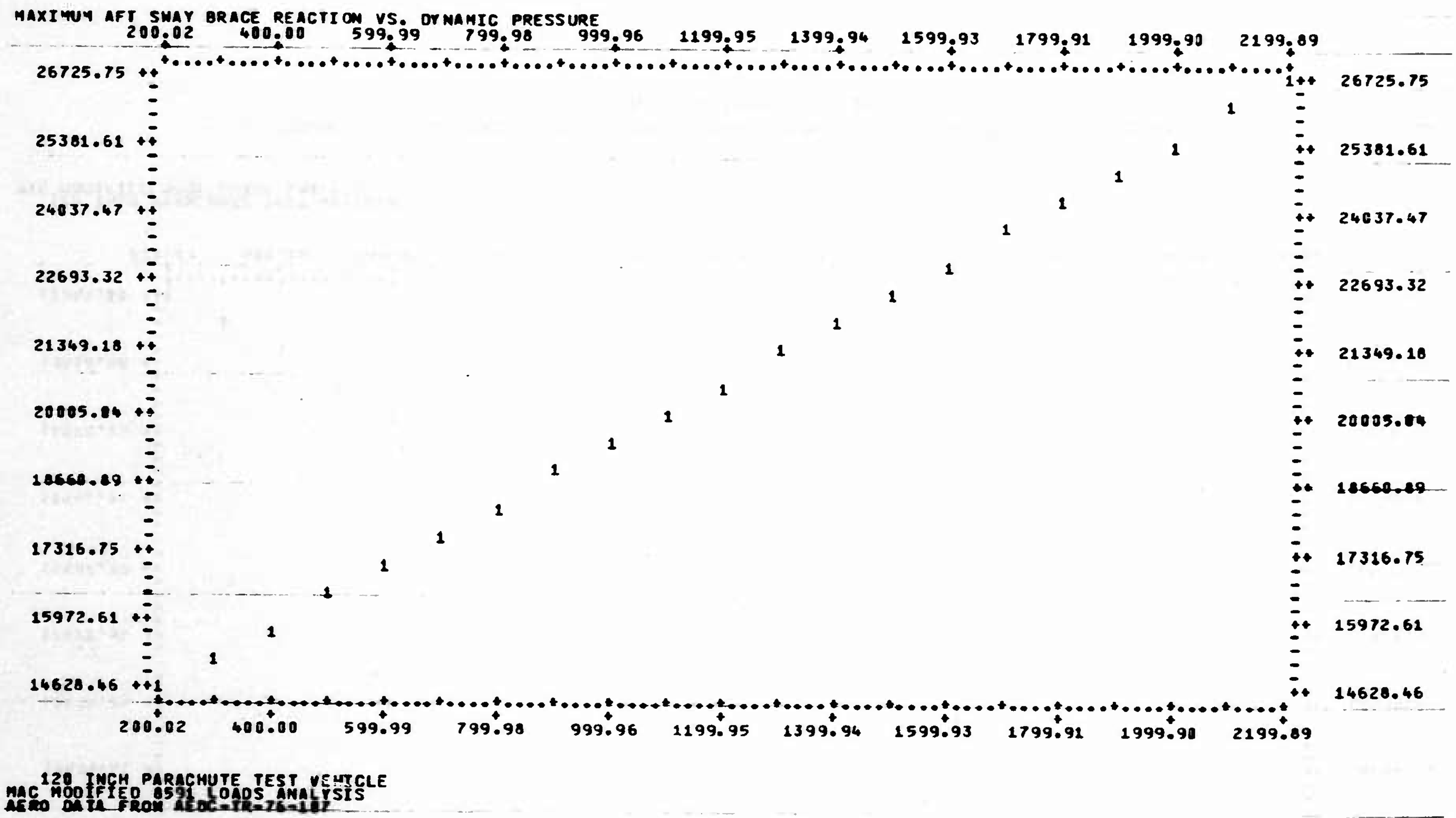


Figure 19. Maximum Aft Sway Brace Reaction Versus Dynamic Pressure for the 120-Inch Vehicle

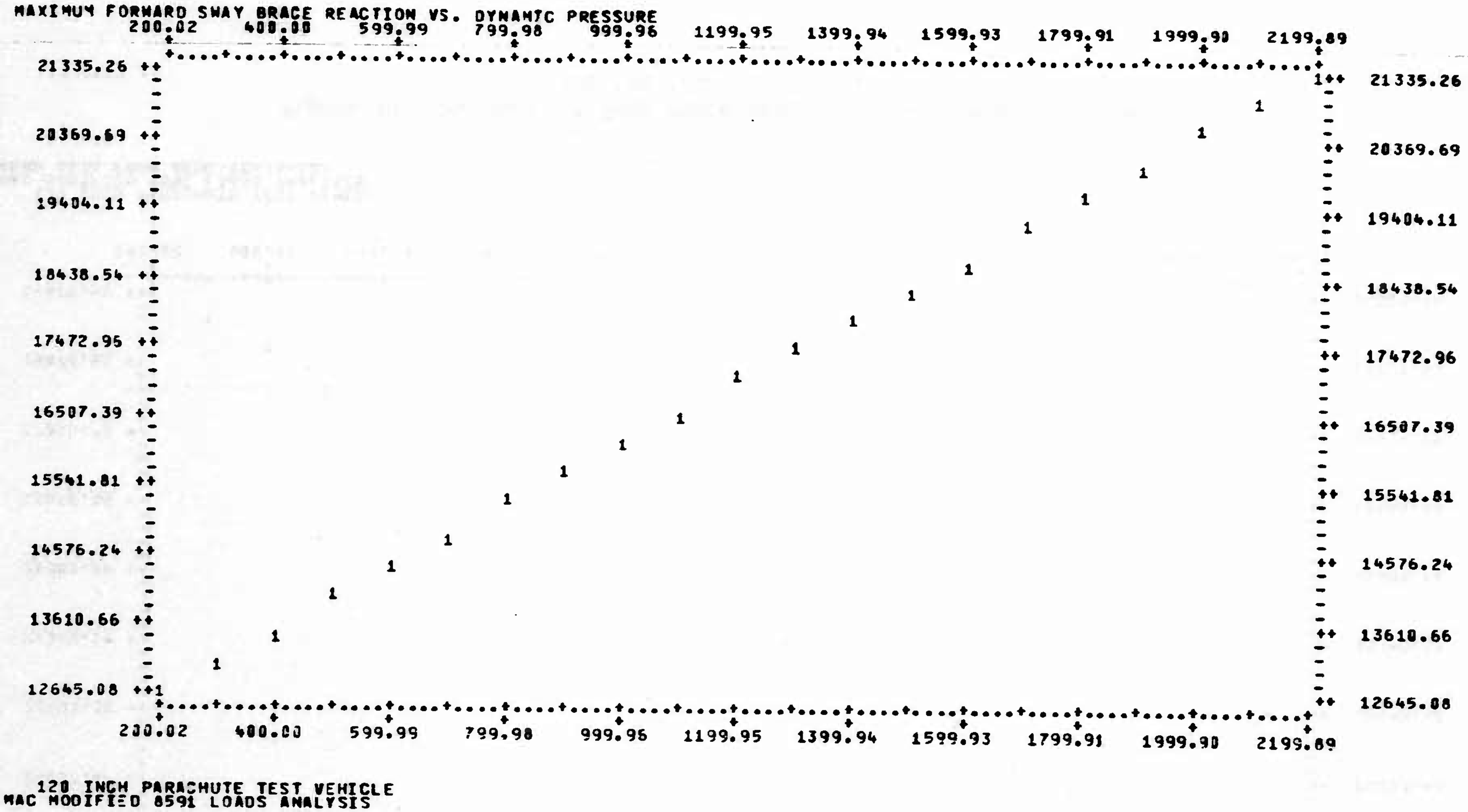


Figure 20. Maximum Forward Sway Brace Reaction Versus Dynamic Pressure for the 120-Inch Vehicle

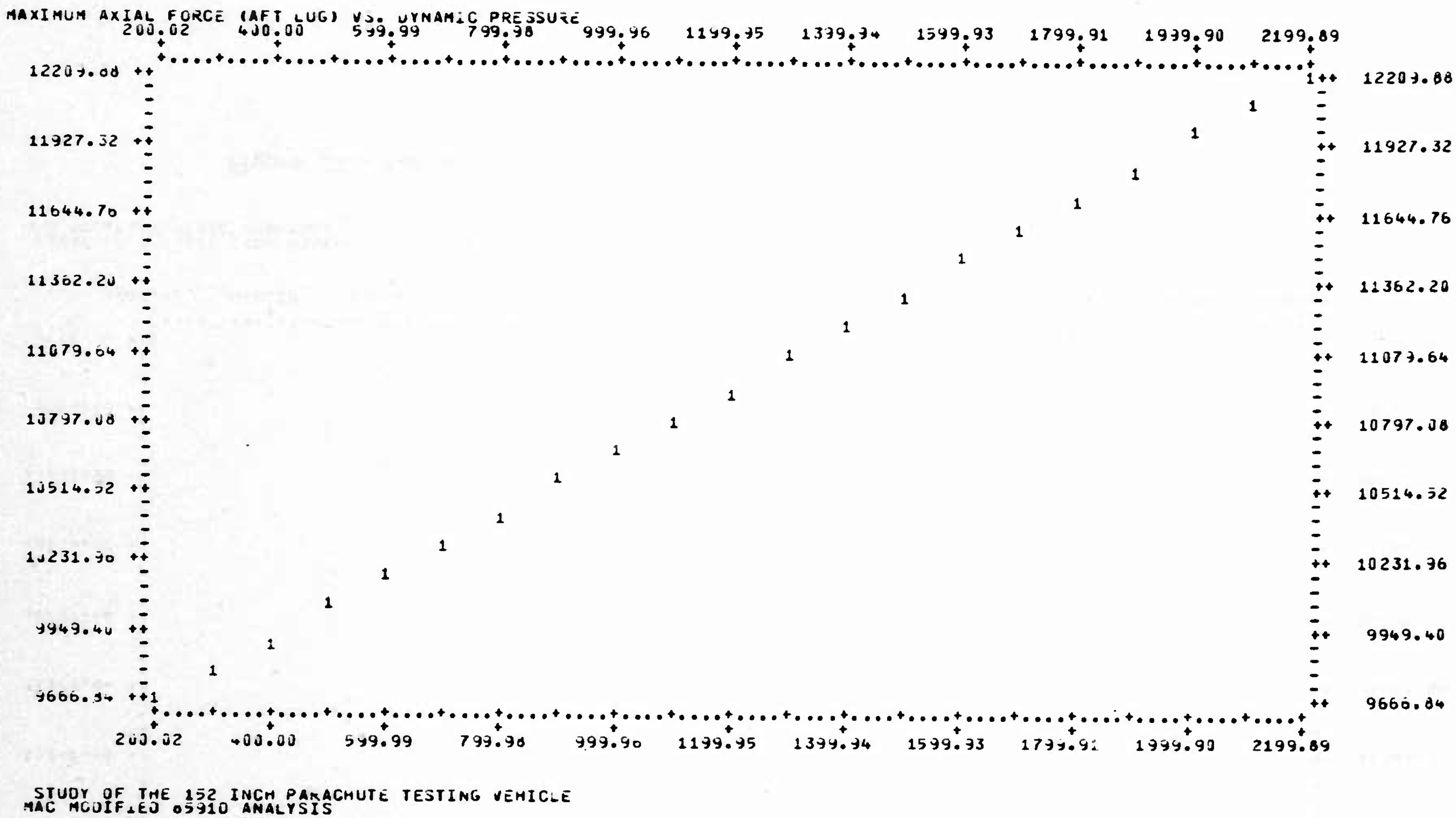


Figure 21. Maximum Axial Force on the Aft Lug Versus Dynamic Pressure for the 152-Inch Vehicle

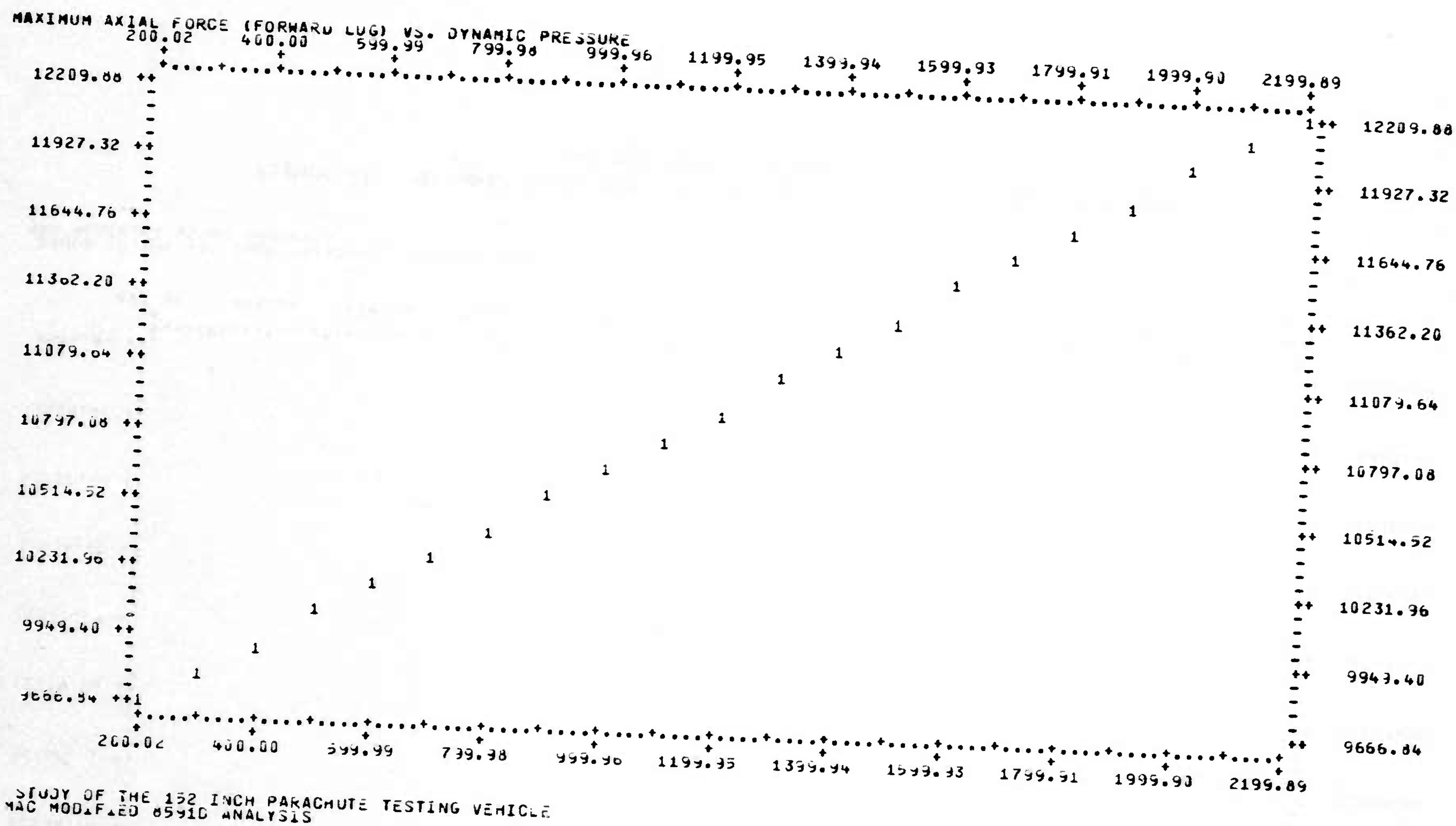


Figure 22. Maximum Axial Force on the Forward Lug Versus Dynamic Pressure for the 152-Inch Vehicle

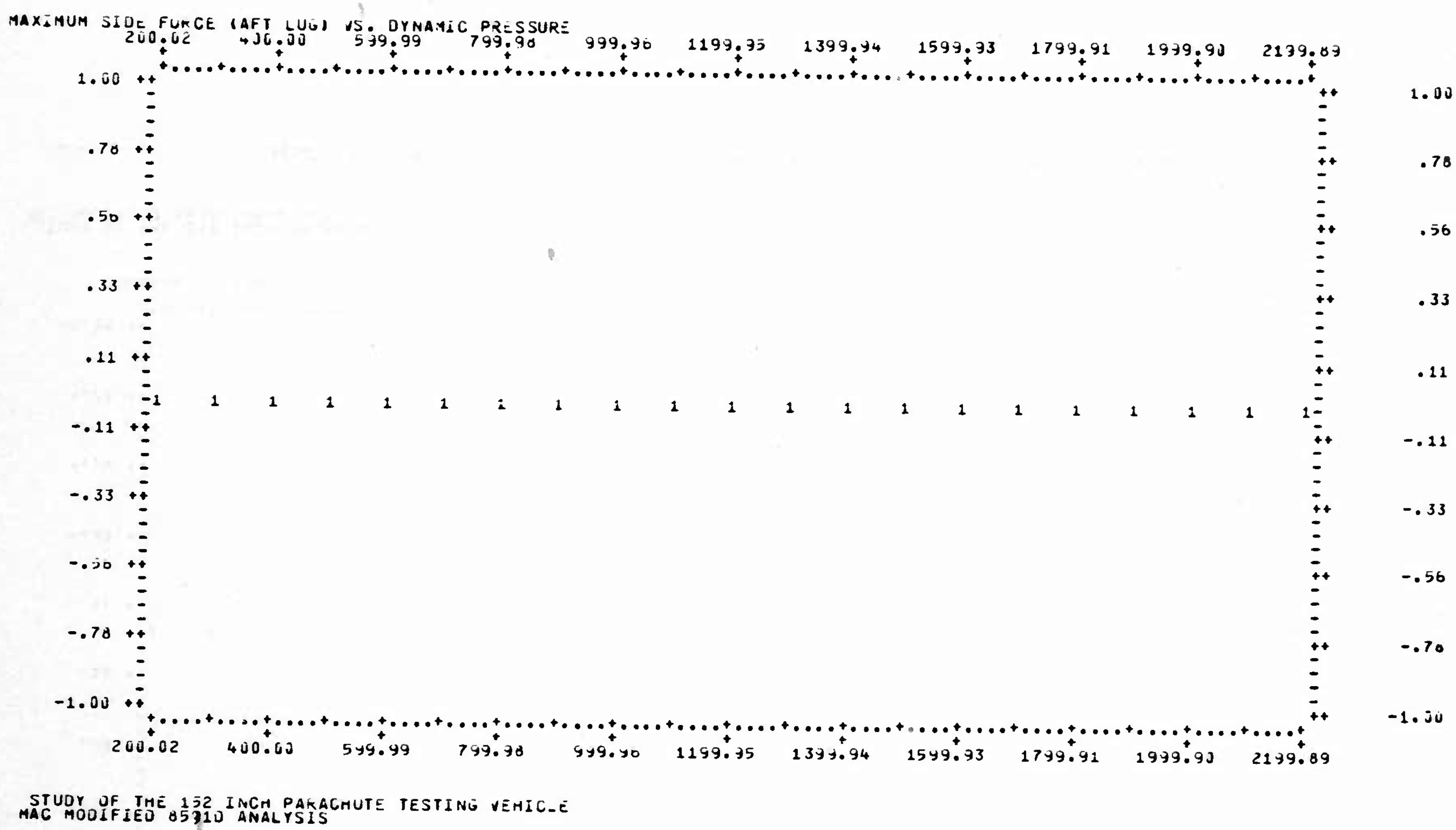


Figure 23. Maximum Side Force on the Aft Lug Versus Dynamic Pressure for the 152-Inch Vehicle

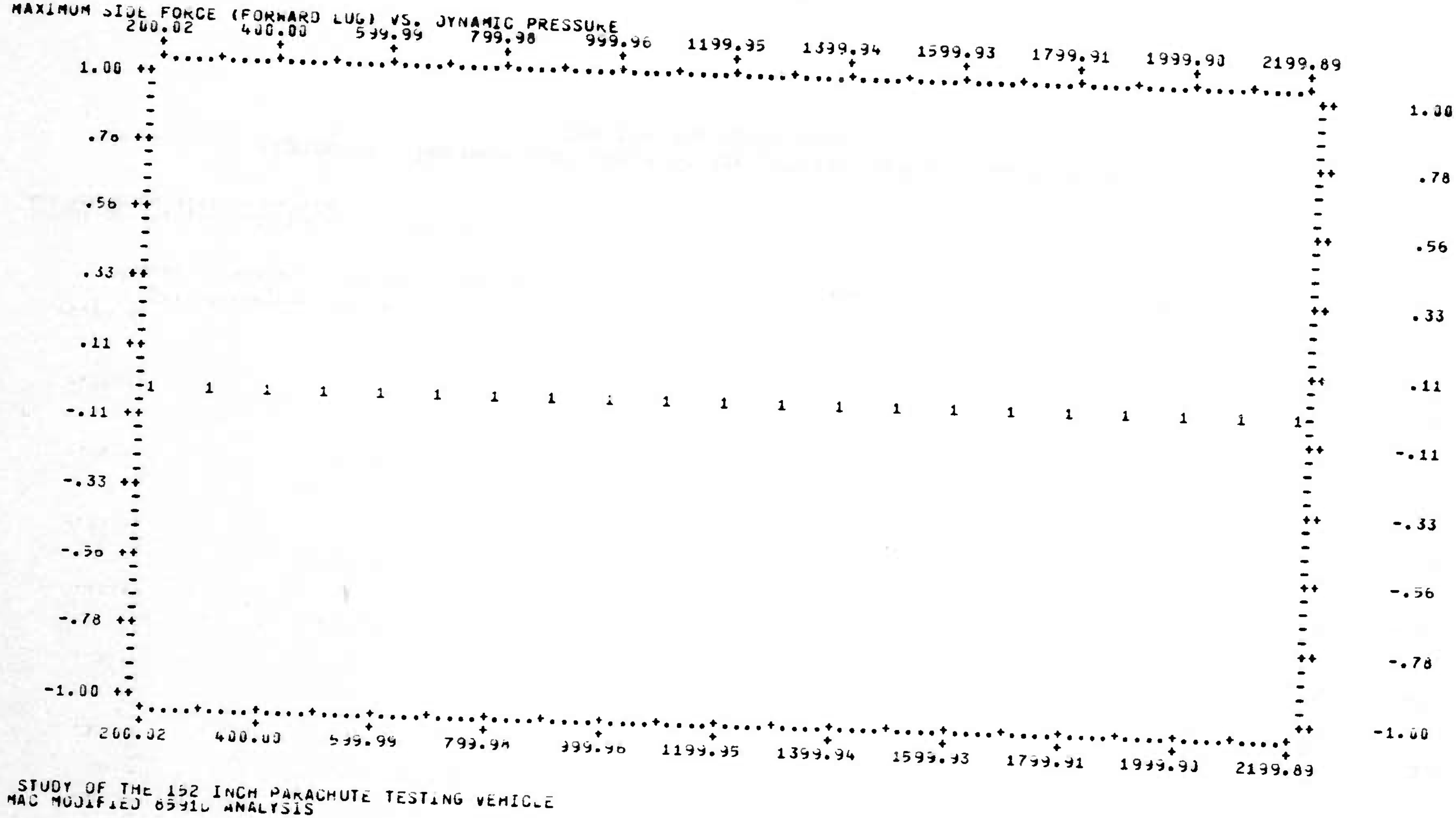


Figure 24. Maximum Side Force on the Forward Lug Versus Dynamic Pressure for the 152-Inch Vehicle

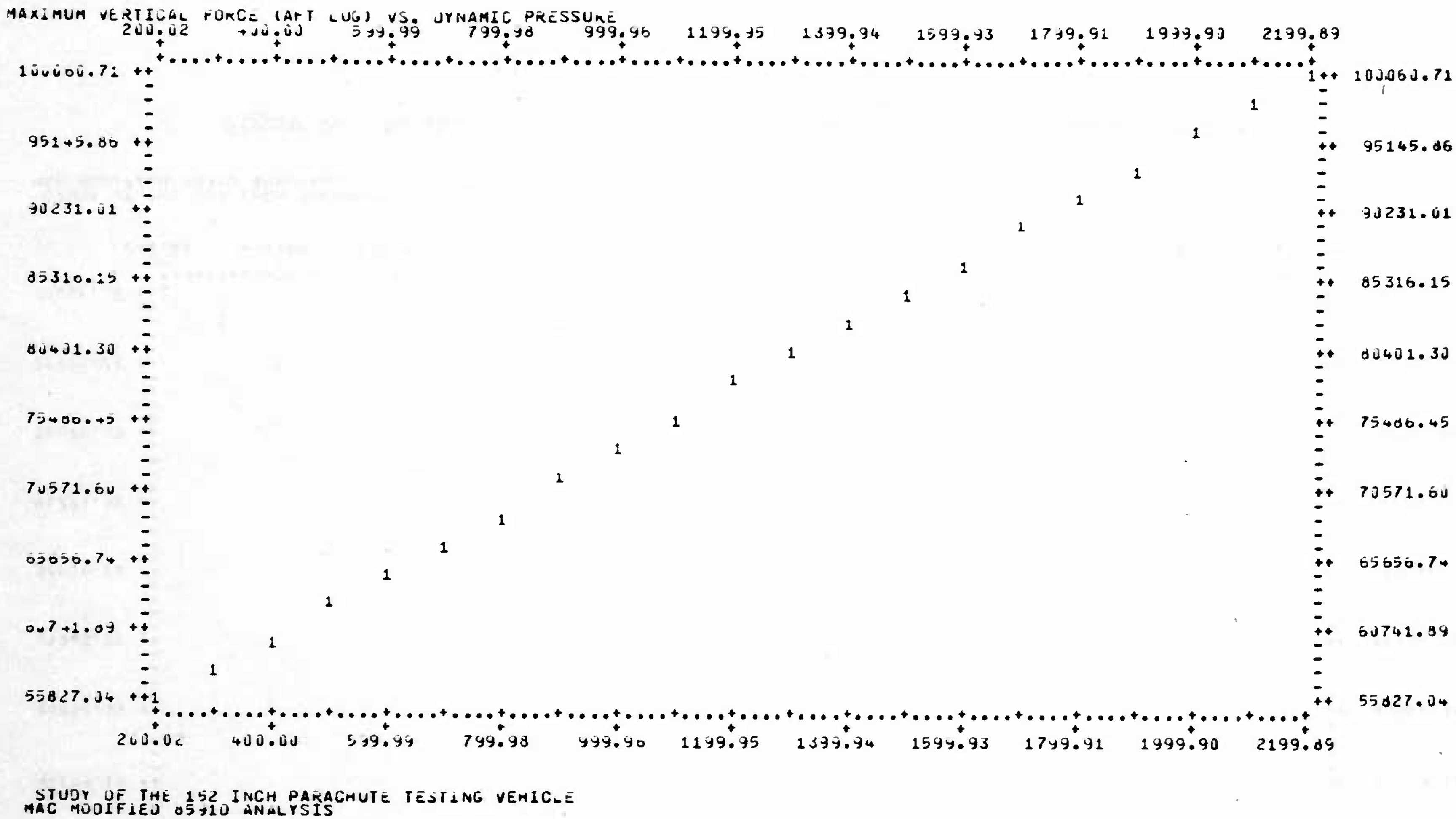


Figure 25. Maximum Vertical Force on the Aft Lug Versus Dynamic Pressure for the 152-Inch Vehicle

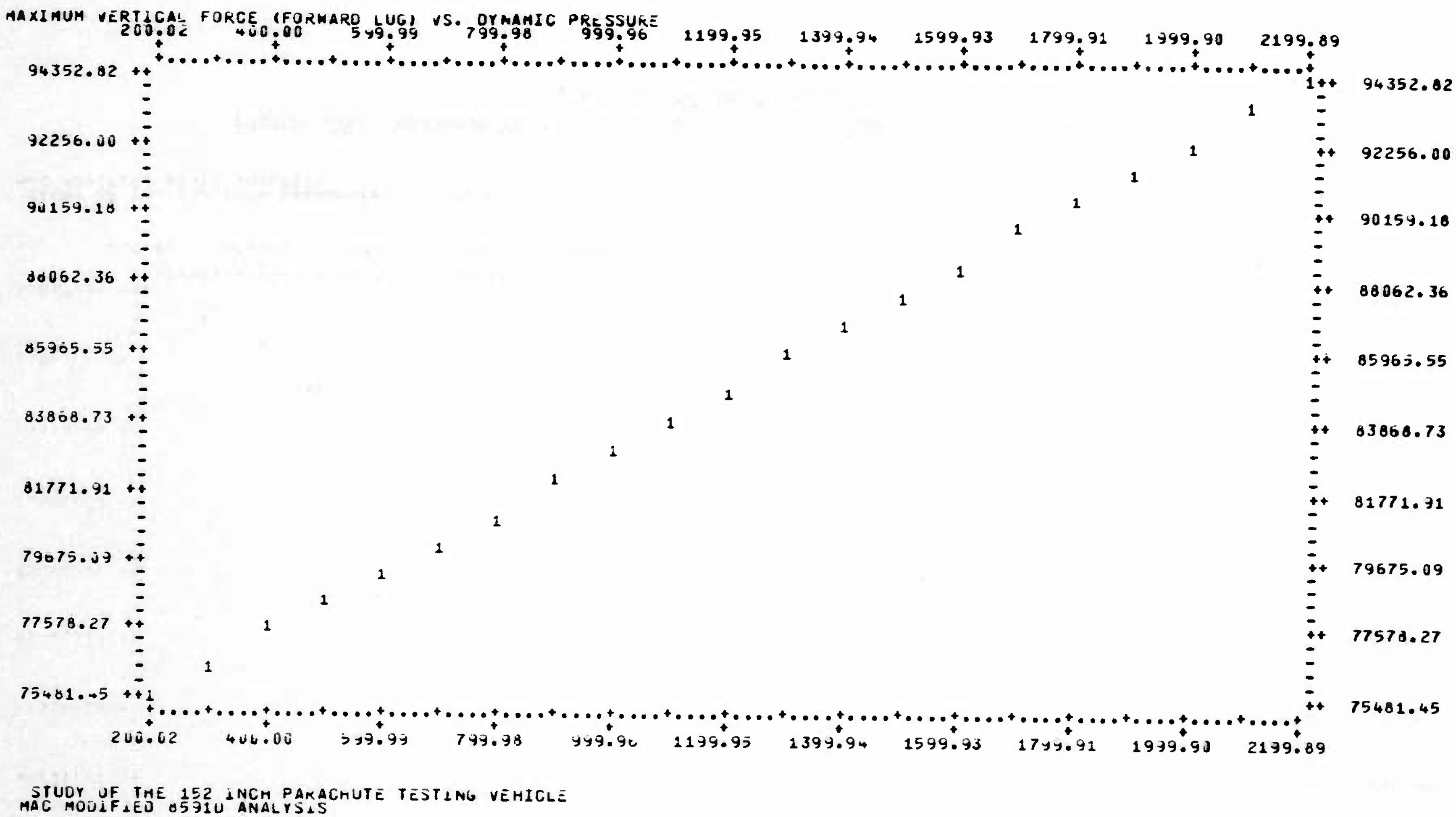


Figure 26. Maximum Vertical Force on the Forward Lug Versus Dynamic Pressure for the 152-Inch Vehicle

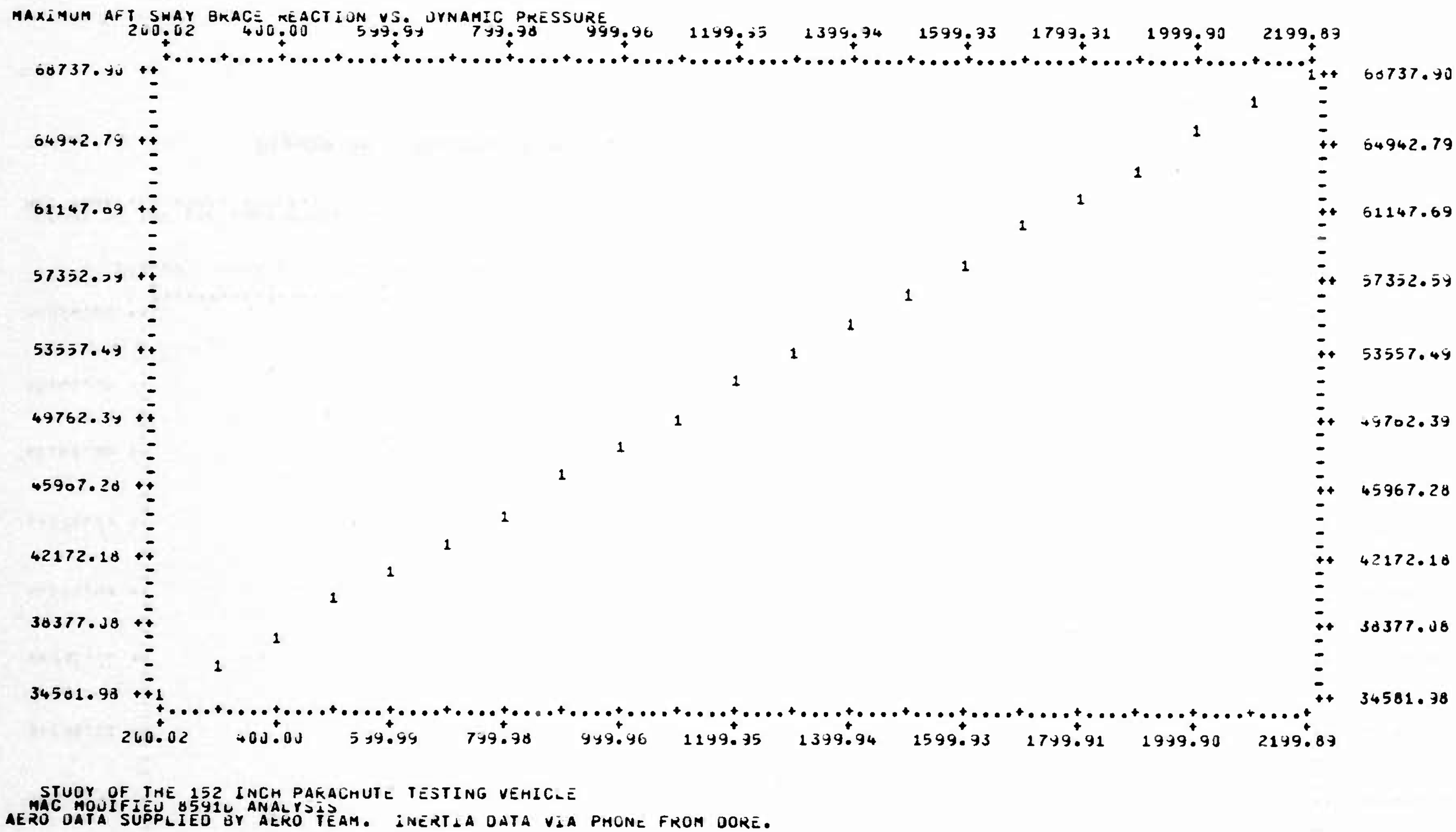


Figure 27. Maximum Aft Sway Brace Reaction Versus Dynamic Pressure for the 152-Inch Vehicle

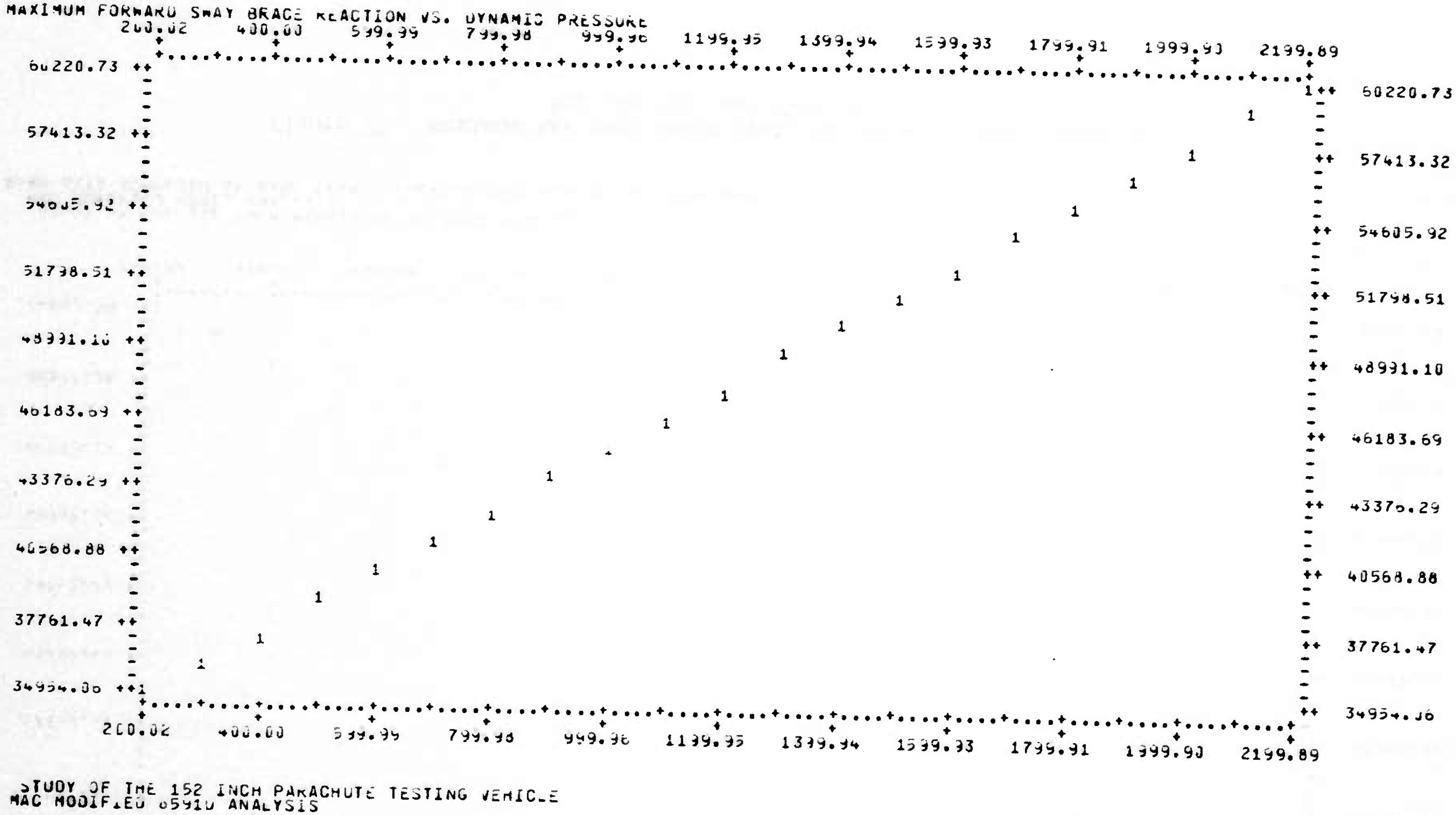


Figure 28. Maximum Forward Sway Brace Reaction Versus Dynamic Pressure for the 152-Inch Vehicle

SECTION V

STRESS ANALYSIS ON VEHICLES AT CRITICAL AREAS

1. GENERAL

For the 0.25-inch skin, both at the welds and elsewhere, the moment of inertia is

$$I = 0.25\pi\left(r_2^{\,4} - r_1^{\,4}\right)$$

$$I = 0.25\pi\left(11.5^4 - 11.25^4\right)$$

$$I = 11.56 \text{ in}^4$$

The maximum bending stress, F_b, will occur at the greatest distance from the neutral axis, i.e., at r_2. The ultimate stress for the welds, $F^{w}_{u_b}$, is assumed at 45,000 psi and that for the skin, $F^{s}_{u_b}$, at 55,000 psi (Reference 4). For further conservation and to make the analysis non-redundant, assume the aft lug-sway brace combination does not react any of the shear load or moment being generated.

For the lug well analysis, assume that the lug well base is attached to the strongback area by a 0.375 fillet weld (Reference 5). Since the base is 3.5 inches in diameter, the total weld length is 11 inches.

2. WELD AT STATION 54 OF 120-INCH VEHICLE

To determine the maximum bending stress

$$F_b = MC/I$$

$$F_b = (428{,}538)\ (11.5)/1156$$

$$F_b = 4263 \text{ psi}$$

Then the margin of safety is

$$MS = \frac{45{,}000}{1.5\ F_b} - 1$$

$$MS = \text{High}$$

3. SKIN AT STATION 65 OF 120-INCH VEHICLE

To determine the maximum bending stress

$$F_b = MC/I$$

$$F_b = (297{,}104)\ (11.5)/1156$$

$$F_b = 2955 \text{ psi}$$

and the margin of safety is

$$MS = \frac{55{,}000}{1.5\ F_b} - 1$$

$$MS = \text{High}$$

4. WELD AT STATION 54 OF 152-INCH VEHICLE

To determine the maximum bending stress

$$F_b = MC/I$$

$$F_b = (1{,}892{,}330)\ (11.5)/1156$$

$$F_b = 18{,}825 \text{ psi}$$

and the margin of safety is

$$MS = \frac{45{,}000}{1.5\ F_b} - 1$$

$$MS = 0.59$$

5. SKIN AT STATION 58 OF 152-INCH VEHICLE

To determine the maximum bending stress

$$F_b = MC/I$$

$$F_b = (1{,}268{,}487)\ (11.5)/1156$$

$$F_b = 12{,}619 \text{ psi}$$

and the margin of safety is

$$MS = \frac{55,000}{1.5\ F_b} -1$$

$$MS = 2.91$$

6. WELD AT STATION 86 OF 152-INCH VEHICLE

To determine the maximum bending stress

$$F_b = MC/I$$

$$F_b = (632,215)\ (11.5)/1156$$

$$F_b = 6289$$

and the margin of safety is

$$MS = \frac{45,000}{1.5\ F_b} -1$$

$$MS = 3.77$$

7. STRONGBACK AREA OF 120-INCH VEHICLE

The shear in the lug well weld is

$$F_s = \frac{P}{(11)(3/8)}$$

$$F_s = 0.2424P$$

For the forward lug

$$F_s = (0.2424)\ (32,400)$$

$$F_s = 7854 \text{ psi}$$

and the margin of safety is

$$MS = \frac{32,000}{(1.5)(7856)} -1$$

$$MS = 1.72$$

For the aft lug

$$F_s = (0.2424)(30{,}000)$$

$$F_s = 7272 \text{ psi}$$

and the margin of safety is

$$MS = \frac{32{,}000}{(1.5)(7272)} - 1$$

$$MS = 1.93$$

Now consider the skin surrounding the lug well and just beyond the weld. The diameter of this circle is

$$d = 3.5 + 0.375 + 0.375$$

$$d = 4.25 \text{ inches}$$

Thus

$$F_s = \frac{P}{\pi(4.25)t}$$

$$F_s = 0.0749 \frac{P}{t}$$

For the forward lug area, the surrounding skin is 0.5 inch thick. Thus,

$$F_s = 0.0749 \frac{32{,}400}{0.5}$$

$$F_s = 4853 \text{ psi}$$

and the margin of safety is

$$MS = \frac{32{,}000}{(1.5)(4853)} - 1$$

$$MS = 3.39$$

For the aft lug area, the surrounding skin is 0.25 inch thick. Thus

$$F_s = 0.0749 \frac{30,000}{0.25}$$

$$F_s = 8988 \text{ psi}$$

and the margin of safety is

$$MS = \frac{32,000}{(1.5)(8988)} -1$$

$$MS = 1.37$$

8. STRONGBACK AREA OF 152-INCH VEHICLE

The shear in the lug well weld is

$$F_s = \frac{P}{(11)(3/8)}$$

$$F_s = 0.2424P$$

For the forward lug

$$F_s = (0.242)\ (86,000)$$

$$F_s = 20,812 \text{ psi}$$

and the margin of safety is

$$MS = \frac{32,000}{(1.5)(20,812)} -1$$

$$MS = 0.025$$

For the aft lug

$$F_s = (0.242)\ (78,000)$$

$$F_s = 18,876 \text{ psi}$$

and the margin of safety is

$$MS = \frac{32,000}{(1.5)(18,876)} -1$$

$$MS = 0.13$$

Now consider the skin surrounding the lug well and just beyond the weld. The diameter of this circle is

$$d = 3.5 + 0.375 + 0.375$$

$$d = 4.25 \text{ inches}$$

Thus

$$F_s = \frac{P}{\pi(4.25)t}$$

$$F_s = 0.0749 \frac{P}{t}$$

For the forward lug area, the surrounding skin is 0.5 inch thick. Thus

$$F_s = 0.0749 \frac{86,000}{0.5}$$

$$F_s = 12,882 \text{ psi}$$

and the margin of safety is

$$MS = \frac{32,000}{(1.5)(12,882)} -1$$

$$MS = 0.66$$

For the aft lug area, the surrounding skin is 0.25 inch thick. Thus

$$F_s = 0.0749 \frac{78,000}{0.25}$$

$$F_s = 23,368 \text{ psi}$$

and the margin of safety is

$$MS = \frac{32,000}{(1.5)(23,368)} -1$$

$$MS = -0.09$$

9. JOINT AT VEHICLE FIN ROOT

The fin is connected to the vehicle by a 1x1x1/8x28-inch angle iron. The leg attached to the vehicle is connected by a 1/8-inch fillet weld.

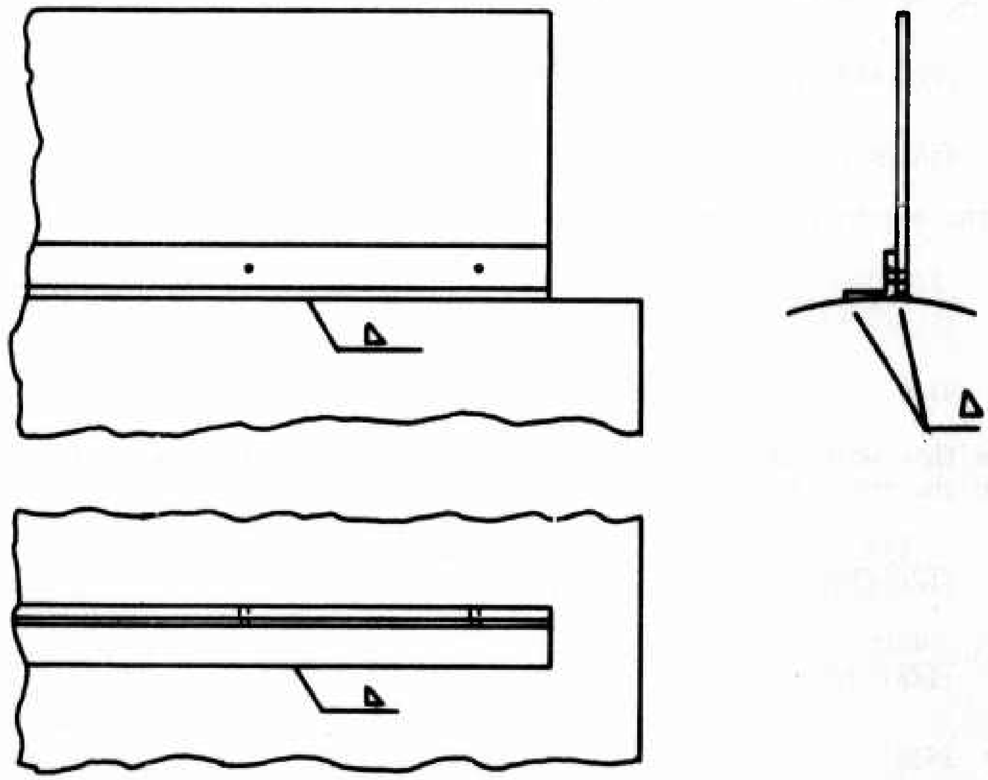


Figure 29. Fin Attach Detail

The other leg is connected to the fin by way of six 1/4-inch-diameter bolts designed to 120,000 psi in tension and 25,000 psi in shear. Assuming that the moment is reacted by the bolts coupled with the reaction at the skin-angle connection (see Figure 29) and that the bolt line is centered 1/2 inch from angle, then the following stress is computed.

$$F_t = 2N/6A_b + S/6A_b$$

where A_b is the area of the bolts

$$F_t = (2)\ (4800)/(6 \times 0.2) + (1600)/(6)\ (0.2)$$

$$F_t = 9333 \text{ psi}$$

and thus the margin of safety is

$$MS = \frac{120{,}000}{(1.5)(9333)} - 1$$

$$MS = \text{High}$$

Now assume that weld reacts the moment as a couple with the edge of the angle then the shear is

$$F_s = \frac{(1)M}{(1/8)(25)}$$

$$F_s = \frac{4800}{(1/8)(25)}$$

$$F_s = 1536$$

Thus the margin of safety is

$$MS = \frac{32{,}000}{(1.5)(1536)} - 1$$

$$MS = \text{High}$$

SECTION VI

RECOMMENDATIONS AND CONCLUSIONS

The load and subsequent stress analysis presented within this document resulted in sufficient margin of safety throughout the envelope to structurally recommend flight to the desired limits. The only weak area indicated by the analysis was the aft lug well area of the heaviest weight item. Since the 6511th Test Squadron already inspects this area after each flight it is not considered necessary to recommend any additional analysis of this area.

This analysis was meant to be, and is, a very rough analysis. Its purpose was to determine if these items could survive flight on an F-4 as cheaply and quickly as possible. To this end, large conservatisms have been brought into the analysis. Had any structural member shown failure during the analysis, a less conservative analysis would have been necessary. However, since no such significant problem was encountered, this additional study was not necessary.

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